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FINAL REPORT

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ACKNOWLEDGMENTS

The contract studies reported herein were conducted by the staffs of the Microbiological Sciences and Biological Safety and Control Departments of the Becton, Dickinson Research Center. Participating in the laboratory and engineering studies during the 23 month period were the following: J. Sliger, R. Lasslett, R. Arnsberger, T. Jenkins, S. Stiner, R. Plaugher, C. Garnett, and S. Bailey. Providing extensive assistance in the administration of the contract studies was R. S. Runkle, Administrative Manager, BDRC. The participation of these individuals is gratefully acknowledged.

ABSTRACT

A decontamination chamber with the unique capability of maintaining set parameters of temperature, relative humidity, pressure and gas concentration was designed and fabricated. After establishing proper operation of the chamber, experimental cycles were started with approximately three months of contract time remaining thereby reducing the number of parametric evaluations initially scheduled. A sufficient number of cycles were conducted to gain some insight into the operation of the chamber and the effects of varying parameters and cycle phases on the efficiency of sterilization of spacecraft-type materials. The test pieces included glass, plastic, and stainless steel strips, capillary tubing, and open and Morton-capped test tubes, which were inoculated in all but one test series with 10^5 - 10^6 spores of Bacillus subtilis var. niger. Morton-capped and capillary tubes were the most difficult test pieces to decontaminate. Stainless steel strips were the easiest test pieces to decontaminate. The results obtained indicated that the most effective cycles were those conducted at 50C, 50% R.H., 800 mg/l ETO, and 16 or 24 hour exposure times. Within these parameters, equivalent results were observed with both preconditioned and non-preconditioned spores and in dynamic as well as static exposures. Preconditioning was carried out at atmospheric pressures in the above cycles. With respect to the individual parameters investigated, relative humidity appeared to have the most pronounced effect on sterilizing efficiency. An improved spore kill was observed when relative humidity was increased from 30% to 50% in the 50C cycles. Effects of gas concentration, time and temperature might have been manifest with further testing. In some ancillary studies, an apparent increase in sterilizing efficiency was observed when plastic strips

containing 10^7 spores were preconditioned _in vacuo_ for 15 to 60 minutes prior to exposure to 50C, 50% R.H., and 400 mg/l ETO for 1 or 2 hours.

INTRODUCTION

This report presents the research conducted by Becton, Dickinson and Company during the period of October, 1968 through September, 1970, in fulfillment of the Jet Propulsion Laboratory Contract No. 952169.

Data presented in this report are related to the development of practical and effective procedures for decontamination of spacecraft components with ethylene oxide as a function of interdependent parameters of gas concentration, time, temperature, and relative humidity. Dynamic conditions were evaluated and compared with static conditions.

Upon issuance of this contract, it was necessary to fabricate a decontamination chamber to meet the requirements of JPL specification VOL-50503ETS. This task was completed by S. Blickman Inc., Weehawken, N. J., the successful bidder for this part of the contract. The completed chamber was comprised basically of a 3 foot diameter by 4 foot long horizontal stainless steel chamber, supported 3 feet off the floor on a mild steel supporting framework. One end of the chamber swings open to provide access to the interior which contains a 2 foot by 4 foot perforated work surface for placement of test samples. When the door is bolted closed, a clear view of the interior is afforded through two 8 inch diameter glass windows in the door. A 4 inch diameter stainless steel pipe runs from the floor of the chamber, near the door, externally to the center of the rear wall of the chamber. A 2HP blower connected within this piping permits circulation of the chamber atmosphere. The dynamic movement is created by drawing the chamber atmosphere through the perforated work surface and into the floor pipe. The floor pipe reenters the chamber through the rear wall and a

baffle plate forces the atmosphere to the top of the chamber where it is forced down through a perforated ceiling into the chamber area proper in which test pieces are placed. All flow is directed through a hot water heat exchanger mounted in the piping system, which provides the sole means of heating and cooling the chamber atmosphere. Details of controls, sensing elements, and auxiliary components and systems are fully described under "Methods and Materials." Chamber cost precluded the complete automation of all systems.

BACKGROUND

During the past 20 years, a significant amount of knowledge has been obtained regarding ethylene oxide gas, especially with respect to its application to the sterilization of heat-sensitive products and medically related items. Many different ethylene oxide sterilizing cycles have been specifically formulated for diverse products and applications. This has been possible because of the various interdependent variables existent in ethylene oxide sterilizing processes. These include temperature, gas concentration, relative humidity, exposure time, and the nature of the product or item to be sterilized. The ability of temperature to influence chemical reaction rates is well known. With respect to ETO, an increase in temperature promotes the rate of diffusion of this agent through packaging materials as well as through the cell wall of microorganisms, thus increasing its lethal activity. Phillips and Kaye (1) demonstrated a 2.74-fold increase in rate of lethal activity per 10C increase in temperature between 5C and 37C at a gas concentration of 884 mg/l. A comparable rate increase was observed by Ernst and Shull (2) below 33.4C using 884 mg/l ETO. At higher temperatures, the lethal activity of the gas increased by a factor of 1.8. Although increased temperature can decrease the necessary exposure time, allowing for shorter cycles, the effect of elevated temperature on heat-sensitive items imposes an upper limit on this variable. For this reason, most ETO sterilization cycles are conducted between 50-60C.

Shorter cycles can also be achieved by using higher concentrations of ETO. Some investigators (2, 3) have shown a more rapid and uniform rate of kill using ETO concentrations of 1000 mg/l or greater. However, very slight or no increase in death rate was observed with increasing concentration

by other workers (4, 5, 6) under similar or slightly different experimental conditions. Thus, the influence of other factors as well as ETO concentration effects is indicated. Ehrlen (7) reported that for practical sterilization using ethylene oxide, concentrations of 500 to 1000 mg/l at 50-60C and 40-80 per cent relative humidity can be employed for 3 to 6 hour exposure periods. In situations where time is not a factor, lower concentrations ranging from 100 to 200 mg/l at ambient temperature and pressure may be employed with a 24-hour exposure period.

Moisture plays an important role in ETO sterilization processes. Its influence on the efficacy of ethylene oxide sterilization processes has been the subject of numerous investigations (6, 8, 9, 10, 11). The moisture content of the microorganism, the nature of the material surfaces on which contaminants are present, and the relative humidity of the atmosphere surrounding the microorganism have all been cited as important factors affecting the efficiency of ethylene oxide gas. In general, it has been stated that excessive dessication of the item(s) to be sterilized should be avoided prior to exposure and that the relative humidity within the area where sterilization is to occur should range between 30 and 50 per cent (12).

Exposure time for materials to be sterilized by ethylene oxide is dependent upon various factors, such as the numbers of contaminating organism on the material to be exposed, the moisture content of contaminants and items, the type of wrapping or other barriers to be penetrated, temperature, and concentration of ETO.

It is often necessary to empirically derive cycle times on a trial and error basis with the use of biological sterility controls. Kinetic studies involving the use of bacterial survival curves may also be employed to estimate the exposure times required to sterilize under a given set of parametric conditions. Kereluk and Lloyd (12) have stated that, in practice, relatively short exposure periods can be achieved at temperatures of 54.4C to 60C and ETO concentrations of 700 to 1000 mg/l provided all materials to be sterilized are thoroughly cleaned and wrapped in approved wrapping materials.

Most of the preceding information has been developed with respect to the sterilization of disposable or heat-sensitive hospital-type materials and the state-of-the-art in ETO sterilization is well established in this and related areas. Very little knowledge has been generated, however, with respect to the application of ethylene oxide as a spacecraft component sterilant although its use for this purpose has been suggested by a number of workers.

Thus, the sterilization of spacecraft components represents a new application of ETO gas and should be explored as fully as possible to establish the feasibility of the use of this agent. Such an investigation would necessarily include a study of the effect of the various parameters of importance in an effort to establish the optimum conditions for this purpose. In addition to the study of classical parameters of sterilization, viz. cycle variables such as time, temperature, gas concentration, and humidity, and load variables such as type of material, surface, and configuration, other novel or innovative features should also be investigated if possible. Thus, the effects of a dynamic vs. static chamber condition

and extended vacuum pre-exposure of load items represent departures from standard procedure and could conceivably have significance in the sterilization process.

The program reported herein was thus undertaken with the objective of investigating the important and basic parameters of ethylene oxide sterilization with specific reference to the application of knowledge obtained to the sterilization of spacecraft hardware.

RESEARCH OBJECTIVES

1. To determine the operational capabilities of the prototype ethylene oxide decontamination chamber.

2. To evaluate sterilizing efficiency by varying the decontamination parameters of gas concentration, time, temperature and relative humidity under dynamic instead of static conditions as employed by commercially available equipment.

3. Perform evaluations to determine which of the test piece configurations provided "worst case" conditions with respect to ease of sterilizing.

4. To provide effective procedures for decontamination of spacecraft surfaces with ethylene oxide.

METHODS AND MATERIALS

Preparation of stock spore suspension

A lyophilized preparation of *Bacillus subtilis* var. *niger* spores (Ft. Detrick strain) was rehydrated to give a 400 ml suspension of 1×10^{10} spores per ml. The primary spore suspension was cleansed by repeated centrifugation and subsequently divided into four 100 ml portions. Three of these stock spore suspensions were refrigerated and one was used for further preparatory procedures which included four additional centrifugation processes for removal of residual debris. The final clean stock suspension contained 1.4×10^{10} viable spores per ml and was free of vegetative cells. Dilution of the suspension in sterile distilled water (1:100) yielded 76 individual bottles containing 50 ml each of a theoretical 1.4×10^8 per ml spore suspension. Enumeration of 16 of the 76 spore suspensions for verification of viable count resulted in an average viable count of 1.5×10^8 organisms per ml (range of 1.2×10^8 - 1.7×10^8) as shown in Table I. Microscopic examinations of the spore suspensions revealed the absence of debris and contaminating microorganisms. Cultures on Trypticase Soy Agar (TSA) containing brilliant green dye confirmed this observation. Non-pigmented mutants of *B. subtilis* var. *niger* were not detected during any of the cultural examinations.

Ethylene Oxide Resistivity of Stock Spore Suspension

Paper strips containing 1×10^5 spores of the specially prepared *B. subtilis* var. *niger* were exposed to ethylene oxide along with similar numbers of commercially prepared spore strips, also containing 1×10^5 *B. subtilis* var. *niger* spores. Groups of both experimental and commercial

spore strips were exposed for intervals of 1, 5, 10, 15, 20, and 30 minutes at 125F, 40% R.H., and 1000 mg ETO per liter. Results from replicate trials, shown in Table II, indicated that the experimental (JPL) spore preparation was somewhat more resistant to ethylene oxide than the commercial spore preparation. Resistivity of the JPL suspension was again determined after 12 months storage at 4C. The results of these tests are shown in Table III.

Selection and preparation of test pieces

The following test pieces were used during this study:

Test Piece	Material	Size
Test tubes (Morton caps)	Glass	20 x 150 mm
Glass tubes (open)	Glass	10 (ID) x 110 mm
Capillary tubes	Glass	1 (ID) x 130 mm
Glass strips	Glass	15 x 50 mm
Metal strips	316 Stainless Steel	15 x 50 mm
Plastic strips	Polypropylene	15 x 50 mm

Test pieces were washed in hot detergent solutions of Alcojet, rinsed three times in distilled deionized water (less than 1 ppm inorganics) and dried.

The packaging and sterilization methods employed for test pieces is outlined in Table IV.

Sterility assurance tests were conducted on 10 of each piece type by placement in Trypticase Soy Broth, or in the case of test tubes, inoculation of each of 10 tubes with 20 ml Trypticase Soy Broth. All pieces were held and observed for 21 days for evidence of microbial growth.

Inoculation and assay of test pieces

A comparative study using the Eppendorf, Oxford, and Hamilton devices and 0.25 ml glass pipette for inoculation of test pieces was conducted.

The Hamilton syringe was removed from further consideration when problems were encountered in fluid inoculum retention. Statistical analyses indicated that the 0.25 ml glass pipette was the most sensitive method used for test piece inoculation (mean spore recovery of $1.22 \times 10^6 \pm 1\%$ with a standard deviation of 0.08). In comparison, inoculation data when using the Eppendorf or Oxford pipettes resulted in mean spore recoveries of $6.7 \times 10^5 \pm 7\%$ and $1.0 \times 10^6 \pm 99\%$, respectively. The standard deviation for the Eppendorf pipette was 0.35 and for the Oxford pipette 3.5. Despite the observation that use of the glass pipette was associated with maximal sensitivity, the Eppendorf pipette was utilized in the inoculation of test pieces. The rationale for the selection was based on the requirement for maximal reproducibility in the quantitative inoculation of all 7500 test pieces, which would have been difficult to achieve using hand-manipulated glass pipettes, and the greater facility associated with the use of a semi-automatic pipette such as the Eppendorf. Test pieces were inoculated under a laminar flow hood with 1/10 ml per piece of a spore suspension containing 1×10^7 spores per ml. Inoculations were performed as follows:

<u>Test tubes</u> - the inoculum was placed in the bottom of the tube and the Morton cap was replaced.

<u>Open tubes</u> - the inoculum was placed in the middle of the tube no less than 50 mm from each end. The tubes were returned to the petri dish.

<u>Capillary tubes</u> - 0.1 ml of spore suspension was drawn up into each tube. Tubes were returned to petri dishes.

<u>Glass, metal, and plastic strips</u> - each strip was inoculated on one side only with 0.1 ml of spore suspension. The petri dish covers were replaced after inoculation.

Following inoculation of the test pieces, they were placed in an incubator at 30-35C for drying. When the test pieces were visually dry, two of each piece were aseptically placed in 50 ml of Trypticase Soy Broth for initial attribute data. Five of each piece were assayed for initial enumeration data.

Recovery of inoculated spores from test pieces

Enumeration assays of inoculated test pieces were performed with the aid of a sonication procedure. For this purpose, a Branson ultrasonicator was used and included a generator, A300; LT-80 tank; and PC-30 power control. During use, the tank fluid consisted of an aqueous solution of 0.3% by volume Tween 80. The temperature of the tank was maintained between 25C and 37C. Tank fluid was adjusted at least 1 inch above the level of the liquid in the tube being sonicated. The sonicator frequency was set at 25 Kc/second and the power output at 64%. Relative to the bottom surface area of the tank this setting corresponded to 2.3 watts/in.^{2}.

Test pieces were placed in 25 x 200 mm screw cap test tubes containing 50 ml of 1% peptone-0.5% Tween 80 solution. The tubes were suspended approximately 1/2 - 1 inch from the tank bottom at 20 positions, corresponding to 4 square inches per tube.

Following a 12 minute sonication treatment, 5.0 ml portions of the peptone water-Tween 80 solution were aseptically pipetted into five 100 mm diameter petri dishes. Dilutions were made as required in sterile distilled water. Twenty ml of sterile molten (50C) Trypticase Soy Agar was added to each plate and the contents were mixed by gentle swirling. After the mixture had solidified, all plates were incubated at 32-35C and colony counts were

recorded after 24, 48, and 72 hours. Negative and low count plates were incubated for an additional 24 hours before the final count.

Data from preliminary studies to determine optimal operating conditions using the sonicator may be found in Tables I, II and III in the Appendix.

Vacuum exposure of inoculated test pieces

As per contract agreement, the influence of pre-exposure vacuum treatment of spores in sterilizing efficiency was investigated. The vacuum exposure of spore inoculated test pieces was conducted in the vacuum chamber at North Carolina State University. The facility is shown in Figures 1-3. Figure 1 shows the vacuum chamber, the dimensions of which are approximately 12 feet in height by 5 feet in diameter. The top of the chamber is removable and two 16 inch diameter ports are located on its side. The two large diffusion pumps are also visible in the photograph. The facility has the capability of achieving a vacuum of 6×10^{-7} torr. Figures 2 and 3 provide additional views of the vacuum chamber facility. Because of its large size, all test pieces were exposed in a single period rather than in batches.

Two separate sets of inoculated test pieces were subjected to vacuum treatment in the facility. The initial set of test pieces was exposed to a vacuum of 10^{-6} torr for a period of 14 days. After removal from the chamber, viability counts were made immediately and after storage for six months under ambient conditions to determine the effect of vacuum exposure on spore survival. These results are summarized in Table V. A second set of test pieces was subjected to 10^{-7} torr for 72 hours prior to exposure to ethylene oxide sterilization cycles.

Test Plans - Phases I and II

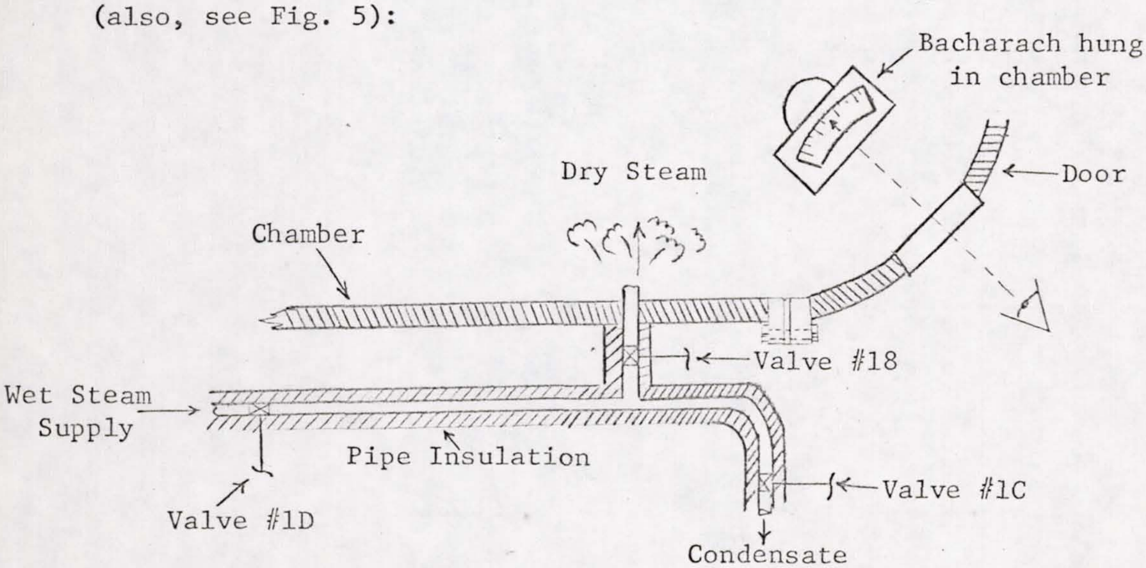
The original Test Plans as formulated prior to initiation of these contract studies may be found in the Appendix.

DESCRIPTION OF CHAMBER

The basic chamber in which the test pieces were exposed is a horizontal stainless steel chamber--3 feet in diameter and 4 feet long, supported 3 feet off the floor on a mild steel open supporting framework (Figs. 4 & 5). One entire end of the chamber swings open to provide easy access to the interior. Inside a perforated work surface has been installed providing a 2' x 4' flat area for holding test samples (Fig. 11). When the door is bolted closed, a clear view of the interior is afforded through two 8" diameter glass "windows" in the door (Fig. 4). A 4 inch diameter stainless steel pipe runs from the floor of the chamber, near the door, externally to the center of the convex rear of the chamber (Fig. 4). A 2 HP blower (Fig. 4) connected into this interconnecting piping permits circulation of the chamber atmosphere. The chamber atmosphere is drawn down through the perforated work surface and into the floor pipe; this pipe reenters the chamber at the rear (Fig. 7) and a baffle plate forces the atmosphere to the top of the chamber where it is forced down through a perforated ceiling. A hot-water heat exchanger (Fig. 7) is mounted in this piping and all flow is directed through this exchanger. This exchanger provides the sole method for heating and cooling the chamber atmosphere.

A mixture of hot and cold water is supplied to this exchanger. A thermostatically controlled "Honeywell Modutrol", 3-way valve assembly, with a separate sensor controls the amount of hot and cold water passing through the copper finned tube construction (Fig. 9). The sensor was originally located inside the chamber in close proximity to the "load," however, the response reaction time lagged so badly that continuous overcompensation was taking place and

exaggerated temperature highs and lows were being recorded. This condition would probably not have existed if the sensor were located close to a large load. To remedy this, the sensor was relocated immediately following the heat exchanger. This proved to be successful. The temperature of the "load" was sensed with a thermistor and continuously recorded on a "Rustrack" 2-inch strip chart. A potentiometer-thermocouple set-up was also used to verify temperature readings and recordings (Fig. 6). In addition, a mercury thermometer was hung in the chamber (Fig. 11). Humidification in the form of steam was originally introduced automatically into the interconnecting piping just ahead of the main heat exchanger. The source of steam was located a considerable distance from the room where this decontamination chamber was installed and wet steam was a continuous problem; getting rid of condensate was a major obstacle. It was decided to introduce the steam directly into the chamber manually, sensing it with a portable Bacharach (Fig. 11) hung in close proximity to the "load" and observed through one of the 8" windows. A diagram will help in understanding this set-up (also, see Fig. 5):



CROSS SECTION TOP VIEW

A record of the Bacharach readings was maintained for each test conducted. Accuracy of the Bacharach was routinely checked with a Sling Psychrometer.

Only one decontaminate was used for this series of tests - 12% ethylene oxide by weight in 88% dichlorodifluoromethane (12:88). This was purchased solely from Pennsylvania Engineering in 140 pound net cylinders (Fig. 4). The liquid passes from the cylinder through a Fulflow filter and into a hot water heat exchanger where it is vaporized and heated to approximately the temperature at which the chamber is being run. A separate thermostatically controlled "Honeywell" modutrol 3-way valve assembly with sensor controls the amount of hot and cold water passing through the exchanger housing (Fig. 7). The 12:88 passes through this exchanger in a double coil of 1/4" OD stainless steel tubing. The sensor is located in the center of these two coils.

A dial thermometer with its probe submerged in the exit water of this exchanger served to monitor the temperature of the vaporized 12:88 as it left the exchanger and passed into the interconnecting piping ahead of the main heat exchanger.

Hot water at a minimum of 180F was supplied to both modutrols from a 4" diameter, 3' long steam heated instantaneous hot water heater hung in the ceiling (Fig. 8).

A 2 HP Siemen & Hinsch water sealed vacuum pump is mounted on one of the supporting framework providing a means for evacuating the chamber (Fig. 12). The rate of evacuation is controlled by two needle valves.

Following any evacuation cycle, the chamber can be backfilled with filtered room air which first passes through a "Flanders" Air Pure Superseal absolute 8" x 8" x 5 7/8" filter (Fig. 7). The rate of backfill is controlled by a butterfly valve and a needle valve. This filter assembly was also used to flush the chamber with filtered air while the vacuum pump was drawing from the opposite end.

Vacuum, pressure and time during each cycle was monitored and recorded on a type 43C "Dickson" Minicorder with an 8" diameter circular record (Fig. 6). As a backup to this recorder, two 4 1/2" dial-size stainless steel Bourdon tube compound gauges were installed on the chamber, one on either side.

The desired ethylene oxide concentration inside the chamber was established by controlling chamber pressure. Using the ideal gas laws and predicated on the fact that the chamber was always evacuated to 15 inches Hg absolute before introduction of vaporized 12:88, graphs (Figs. 13-15) were constructed of chamber pressure vs. ETO concentration for the three temperatures investigated--30C, 40C and 50C. Once the calculated pressure for the desired concentration was established in the chamber, a sample was passed through a Mine Safety Appliance Model 300 Low Infrared Analyzer and if the actual concentration was not within $^{+50}_{-25}$ mg/l of the desired point, the pressure in the chamber was suitably adjusted. A 1 pound pressure adjustment changed the concentration by 29 mg/l when using 12:88. This final pressure in the chamber was automatically maintained by a "United Electric" dual switch pressure controller (Fig. 6).

The decontamination chamber was installed in an area of high relative humidity and temperature. When cycles were attempted at 30C and 30% R.H. and even 40% R.H. neither parameter could be attained. Originally it was found that if only cold water was allowed to pass through the main heat exchanger, the chamber temperature could be reduced and natural conduction would warm the chamber sufficiently to preclude the need for any hot water. However, with the change in the thermostat sensor, the modutrol would close off the hot water supply to a trickle and would maintain the chamber at a temperature of 30C. If hot water at 180F was allowed to enter the heat exchanger the chamber temperature immediately overshot the 30C by a considerable margin and a mixed water supply would not reduce the chamber temperature.

It soon became apparent that a drying column (Fig. 7) would have to be added to the chamber in order to reduce the prevailing ambient relative humidity inside the chamber. A stainless steel drying column was ordered from S. Blickman. The column contains 5 pounds of Union Carbide's silica and alumina molecular sieves which are capable of extracting and retaining 0.9 pounds of water. These can be regenerated by heating them to 400-600F in a vented oven for 1 hour.

SPECIFICATIONS

Becton, Dickinson Decontamination Test Chamber
General Assembly Component Listing
O.O.#44068 Cust. #10866 Mfg. #17542

1. Chamber, recirculation outlet control valve, "Keystone," positive shut-off butterfly 4" valve, fig. 100 with Keystone handle, aluminum body, resilient seat material of neoprene, and stainless steel disc, stem and non-lubricated bushings.

2. Manifold of stainless steel, 4" nom., Sch 5 pipe and 150# flanges.

3. Motor-blower recirculation assembly of stainless steel housing with interior mounted "Standard Electric Mfg. Co." pressure PB 60 blower, ball bearing and polyvinyl-chloride corrosion resistant finished inside, outside and blade wheel and exterior 2 h.p. AC motor with "Boston" FC coupling No. FCR 15 (5/8" hole dia.) and thru chamber rotary seal, "Syntron" RP/Mechanical Shaft Seal for 3/4" dia. Shaft-Force Cooling-Water Outside Liquid Model RP-24.

4. Heat exchanger assembly of 3/16" thick stainless steel 24" OD x approx. 12 1/2" high with bottom gasketed, exchanger mounting disc with exchanger opening cutout, top gasketed flange and removable 14, 380 BTU per hour heat exchanger with 180° F. water temp., 20° F. temp. drop, 1.97 gal. per min. required and of copper fin. tube construction.

5. Chamber, recirculation inlet control 4" valve (Keystone).

6. Recirculation system, filtered room air, inlet control 4" valve (Keystone).

7. Inlet, room air, filter housing of stainless steel with a stainless steel 1/4" needle, decon. control valve and a "Flanders" air pure superseal absolute filter No. 7C70-SL, 8" x 8" x 5 7/8" with gasketed frame.

8. Inlet, room air, filter block control 2" valve (Keystone) for filter decontamination.

9. Chamber manual exhaust control valve "DYNA-QUIP" No. V8TC2-1, 1/2" Thrd. Ends, .375" port size, 316 stainless steel ball and body and teflon seat and stem material.

10. Automatic pressure control manifold (vacuum) block control valve "DYNA-QUIP" No. V8TC2-1.

11. Automatic pressure control, exhaust valve, "ALCO" 2-way solenoid, norm. closed, stainless steel, 1/2" F.P.T. ends, 7/16" orifice with max. oper. pressure differential (air/gas) 125, #8210A37-AC-110V.

12. Stainless steel 1/2" O.D. tubing.

13. Hot water inlet connection 1/2" x 3/4" brass bull tee.

14. Cold water inlet connection 1/2" x 3/4" brass bull tee.

15. Modutrol valves, 1/2" brass pipe manifolding.

16. Heat exchanger, modutrol valve assembly of "Honeywell" cat. Nos. 3-way valve-1/2" IPS screwed-V5013A1187, linkage-Q455C, motor-M944A, compression fitting-761-7P and sensor (Stn. Stl.) 55° F. to 175° F. - T991A1202.

17. Heat exchanger water inlet connection.

18. Heat exchanger water outlet connection.

19. ETO heat exchanger, modutrol valve assembly of "Honeywell" cat. No. 3-way valve 1/2" IPS screwed, linkage, motor, compression fitting and sensor (copper) 55° F. to 175° F.-T991A1244.

20. ETO heat exchanger water supply manual 1/2" brass shut off valve.

21. ETO heat exchanger water inlet 1/2" manifold connection.

22. ETO heat exchanger, outlet manifold connected "Marsh" #99 thermometer 20 to 240° F., 2 1/2" stem 1/4" IPS fitting.

23. ETO heat exchanger water outlet 1/2" brass manifold.

24. Stand mounted mild steel, manifold drain tank.

25. Chamber evacuation pump, #SIHI liquid ring vac. pump CL02702 KK, standard construction with stainless steel shaft, vac. cast tin/bronze impellers and iron housing, mtd. on structural stl. base and driven thru a 2 H.P., 208 V. 3 PH. 60 H_z 4 wire motor. Coupling provided with suitable guard. Pump piped with a 110 v. solenoid valve, regulating valve and shut-off valve for water supply (Hydro-Flow).

26. Pump evacuation connection port.

27. Pump exhaust/drain manifold, mild steel.

28. Chamber, stainless steel evacuation connection manifold.

29. Chamber, stainless steel evacuation control valve, "Vactronic" angle, sweat connection for 2" O.D. tube with stainless steel bellows and viton "A" sealing material, No. CVS225R-W with adapter rings.

30. Evacuation manifold, stainless steel needle evacuation speed control valve.

31. Evacuation manifold/pump flexible connection and clamps.

32. ETO heat exchanger approx. 1500 BTU per hour of 1/4" OD stainless steel tubing removable from stainless steel 1/8" thick housing with gasketed end plates.

33. ETO heat exchanger connection of modutrol valves (#22) sensor -T991A1244.

34. Decontaminates, supply block control valve, "Hoke", bar stock needle globe valve, stainless steel with 1/2" NPT female connections and blunt stem point, #2215F4Y.

35. Decontaminates, supply manifold of stainless steel 1/4" OD tubing.

36. ETO, demand and supply control valve "ALCO" 2-way solenoid, norm. closed, stn. stl. 1/2" F.P.T. ends, 7/16" orifice with max. oper. pressure differential (air/gas) 500, S37-AC-115V.

37. Decontaminates, introduction, chamber/manifold, manual block control valve, "DYNA-QUIP" No. V8TC2-1, 1/2" thrd. end, .375" port size, 316 stainless steel body and ball, and teflon seat and stem seal material.

38. Chamber mtd. compound gage 30" vac. - 30 PSI. (Danton)

39. Manifold furnished 1/2" IPS connections for general purpose readout connection as may be required.

40. Chamber furnished stainless steel full 1/2" IPS couplings, plugged, for customer's use.

41. Chamber furnished stainless steel coupling with "Farris Eng." Type 1875 pressure relief valve mechanically operated, spring loaded and set to open at 30 PSIG.

42. Chamber furnished stn. stl. 1/8" IPS couplings with "CONAX" electrical conductor sealing gland for recorder-controller, feed-thru connections (#44 and #46).

43. Minicorder, "Dickson" type 43-C design 2, panel mounted 24 hour chart #427, electric chart movement, range 0 to 30" vacuum and 0 to 60 PSI, with 1/4" male bottom connection.

44. Temperature recorder, "Rustrack" 2" strip chart with thermister probe recorder single channel model 2133 range 15° C to 65° and "Gulton" L789 thermister bead only with 3" leads.

45. Hygro-therm indicating/controller, "Amlab", single point, humidity range 20 to 100% R.H. temperature range 20 to 60° C. with separate recorder.

46. Humidity recorder, "Amlab" - "Rustrack" type 2" strip chart.

47. Panel mtd. "United Electric" type H27A, model #146 dual switch pressure control to activate ETO inlet solenoid valve #39 and exhaust solenoid valve #14, range 0 - 30 PSI.

48. Panel mtd. thermostat controller for heat exchanger modutrol valve.

49. Panel mtd. thermostat controller for ETO heat exchanger modutrol valve.

50. Exterior of chamber wall mtd. modutrol valve, cover transformer #130810A for heat exchanger.

51. Exterior of chamber wall mtd. modutrol, cover transformer #130810A for ETO heat exchanger.

52. #5252 "Hubbell" Duplex recept. (ref. wiring diagram).

53. #5252 "Hubbell" Duplex recept. (ref. wiring diagram).

54. "Industrial Timer" CM-4 cam timer with C12 gear rack 115V. - 60 H_z single phase for control of (#9) humidity introduction solenoid control valve.

55. Stand mtd. mild stl. electrical control panel.

56. Push button control station with indicating light and key lock, for control of evacuation pump (#28).

57. Balder 2 H.P. AC motor; 115/230 volts, 3450 rpm, for operation of recirculation blower assembly (#3).

58. Electrical junction box (ref. wiring diagram).

59. Main fused safety disconnect switch for entire unit to which all wiring shall be <u>by others</u>. (Ref. wiring diagram) 120/208 volts 3 PH 4 wire 60 H_z with equipment ground.

60. Magnetic motor starter with overload protection for the evacuation pump (#28).

61. Cold water connection tee for water supply to shaft seal, (Item #3).

62. Pressure regulator for shaft seal water supply.

63. "U. S. Gauge" 0-100 PSIG gauge for water supply to shaft seal.

64. Copper, 1/4" OD water supply manifold to shaft seal.

65. "Jarett" No. 605 outlet control valve for shaft seal water return manifold.

GENERAL FABRICATION SPECIFICATIONS
BECTON - DICKINSON
DECONTAMINATION - TEST - CHAMBER
00.44068 MFG. 17542
(BX-5039-1177-10)

Chamber shall be fabricated of type 304 stainless steel all welded construction with all interior welds ground smooth and polished to match other surfaces. Interior of unit only to have a No.4 SATIN finish.

Exterior of unit to have all burn marks, weld spatter, and burrs removed and the matl. finish shall remain unpainted.

Any sharp edges on the interbr or exterior must be removed.

Mild steel support stand and instrumentation mounting panels shall be painted with light gray acid resistant paint.

Components shall be furnished of materials as designated on componen listings.

Chamber and related components shall be fabricated and assembled for required operational use at 35 PS1 and ultimate vacuum of evacuation system as furnished.

S. BLICKMAN, INC.			
536 Gregory Ave., WEEHAWKEN, N. J.			
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REV.- 3-20-69		FOLDER	F
		DWG. INDUST.	

BR-5039-1177-10

1. Upper instrumentation mtg. panel of mild steel, tack welded to chamber body.

2. Lower instrumentation mtg. panel.

3. Stn. stl. full cplg. cont. welded into chamber (half in - Half out

4. Compound gauge. Qty. one.

5. Stn. stl. full ½" I.P.S. cplg. cont. welded into chamber (half in-half out) and furnished with plug. Qty. Seven (six with plugs)

6. Stn. stl. full 1/8" I.P.S. cplg. cont welded into chamber (half in half out) Qty. four.

7. "CONAX" or equal, electrical conductor sealing gland for recorder-controller, feed-thru connections. Qty. four.

8. Stn. stl. full ¼" I.P.S. cplg. cont. welded into chamber (half in-half out) Qty. two.

9. Instant-reset timer, PAB-60S, or equal, with 60 second max. time cycle and one second dial divisions to be wired in conjunction wit "AMLAB" controller (No17) and solenoid valve (REF. MANIFOLD ITEM for humidity introduction upstream of the heat exchanger. Qty. One

10. Variable speed controls for recirculation blower.

11.

12. Automatic pressure control, "United Electric" or equal, type H5 model 354 with calibrated range 0 to 50 PS1, 2½ PS1 dial div., proof pressure - 75 PS1, double throw circuit and with stn. stl. bellows, to activate inlet, solenoid control valve (REF. MANIFOLD ITEM #48) and exhaust, solenoid control valve (REF. MANIFOLD ITEM 5 Qty. One.

13. "SWAGELOK" male elbow, stn. stl. PT No. 400-2-4-316, ¼" tube O.D.-¼" M.P.T. Qty. One.

14. Stn. stl. ¼" O.D. tubing.

15. SWAGELOK"male connector, stn. stl. PT. No. 400-1-4-316, ¼" tube O.D. - ¼ O.D. - ¼ M.P.T. Qty Two.

15A "SWAGELOK" female connector, stn. stl. PT. No. 400-7-4-316, ¼" tube O.D. - ¼" F.P.T. Qty One.

16. "DICKSON", or equal, MINICORDER type 43-C design 2, panel mtd. 24 hour chart #427, electric chart movement, range 0 to 30" vacuum and 0 to 60 PS1, with ¼" male bottom connection. Qty. One.

17. "AMLAB", or equal, hygro-therm indicating/controller, temperature indicator range 20 to 60 $^{\circ}$C and humidity indicator range 20 to 100% R.H. with control to be double set point. Qty. one

18. "AMLAB", or equal, temperature recorder, Rustrak type - 2" strip chart. Qty. One.

19. AMLAB", or equal, humidity recorder, Rustrak type - 2" strip chart. Qty. One.

20. Pressure relief valve, mechanically operated, spring loaded. Set to open at 33 PSIG. Qty. One.

DECONTAMINATION. TEST. CHAMBER
RECIRCULATION-HEATING-HUMIDITY
AND DECONTAMINTES INTRODUCTION
MANIFOLDING

S. BLICKMAN, INC. 536 Gregory Ave., WEEHAWKEN, N. J.	
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REV.- 3-20-67	FOLDER B
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BX-5039-1177-80

40. SWAGELOK", cap, PT. No. 400-C-316 stn. stl. $\frac{1}{4}$" tube O.D. QTY. ONE

41. Removable, SECURED TO INSTRUMENTATION MTG. PANEL) ETO heat exchanger approx. 1500 BTU per hour of $\frac{1}{4}$" O.D. STN. STL. tubing] removable from stn. steel 1/8" thk. housing approx 7" O.D. X 16" lg. furnished with silicone gasketed end plates. QTY. ONE.

42. "SWAGELOK" (bored through) reducer PT. No. 400-R-10-316, stn. stl $\frac{1}{4}$" O.D. TUBE welded to heat exchanger housing, removable cover plates. QTY. TWO.

43. E.T.O. heat exchanger (#41), hot and cold water mixing valve. QTY. ONE.

44. E.T.O. heat exchanger, dial thermometer. QTY. ONE.

45. E.T.O. heat exchanger, temperature controller for mixing valve. QTY. ONE.

46. "SWAGELOK" male connector, PT No. 400-1-8-316 Stn. Stl., $\frac{1}{4}$" tube O.D. X $\frac{1}{2}$" M.P.T. and "SSP" 90° EL. PT. No. 4 SWE ($\frac{1}{4}$" tube O.D.)

47. SWAGELOK" male connector PT. No. 810-1-8-316, stn. stl. $\frac{1}{2}$" TUBE O.D. $\frac{1}{2}$" M.P.T. QTY. ONE.

48. ETO, demand and supply control valve, "ASCO, or equal 2-WAY SOLENOID, norm. closed, valve stainless steel, $\frac{1}{2}$" F.P.T. ends 5/16" origice with max oper. pressure differential (AIR/GAS) 40 P.S.1. QTY. ONE.

49. Chamber manual exhaust control valve, "DYNA-QUIP", or equal No. V 8 TC 2-1, $\frac{1}{2}$" THIRD END, .375 port size, 316 stn. stl. body, teflon seat and steam real matl., and 316 stn. stl. ball. QTY. 1

50. Automatic pressure control manifold (VACUUM) BLOCK CONTROL VALVE "DYNA-QUIP" or equal No. V 8TC 2-1. QTY. ONE.

51. Automatic pressure control, exhaust valve, "ASCO", or equal, 2-Way SOLENOID, norm. closed valve stainless steel, $\frac{1}{2}$" F.P.T. ends 5/16" orifice with max oper. pressure differential (AIR/GAS) 40 P.S.1. QTY. ONE.

MANIFOLDING TO THE FOLLOWING DESIGNATED
CONNECTIONS SHALL BE MADE BY OTHERS

A. Water in and water out for item #18, heat exchanger, with inlet, hot and cold water mixing valve.

B. ETO Heat exchanger, inlet connection with hot and cold water mixing valve.

C. ETO Heat exchanger, $\frac{1}{2}$" Nipple outlet connection.

D. Humidity introduction manifold, strainer.

E. Chamber, manual exhaust control valve.

F. Automatic pressure control, exhaust valve.

G. Filter decon control valve.

NOTE:

All pipe and tubing to be type #304 stainless steel.

All flanges to be 150 lbs. and for schedule 5 pipe.

All pipe and related fittings to be schedule 5.

All "SSP:" fittings are #316 stn. stl.

DECONTAMINATION . TEST . CHAMBER
RECIRCULATION-HEATING-HUMIDITY
AND DECONTAMINATES INTRODUCTION
MANIFOLDING

S. BLICKMAN, INC.
536 Gregory Ave., WEEHAWKEN, N. J.

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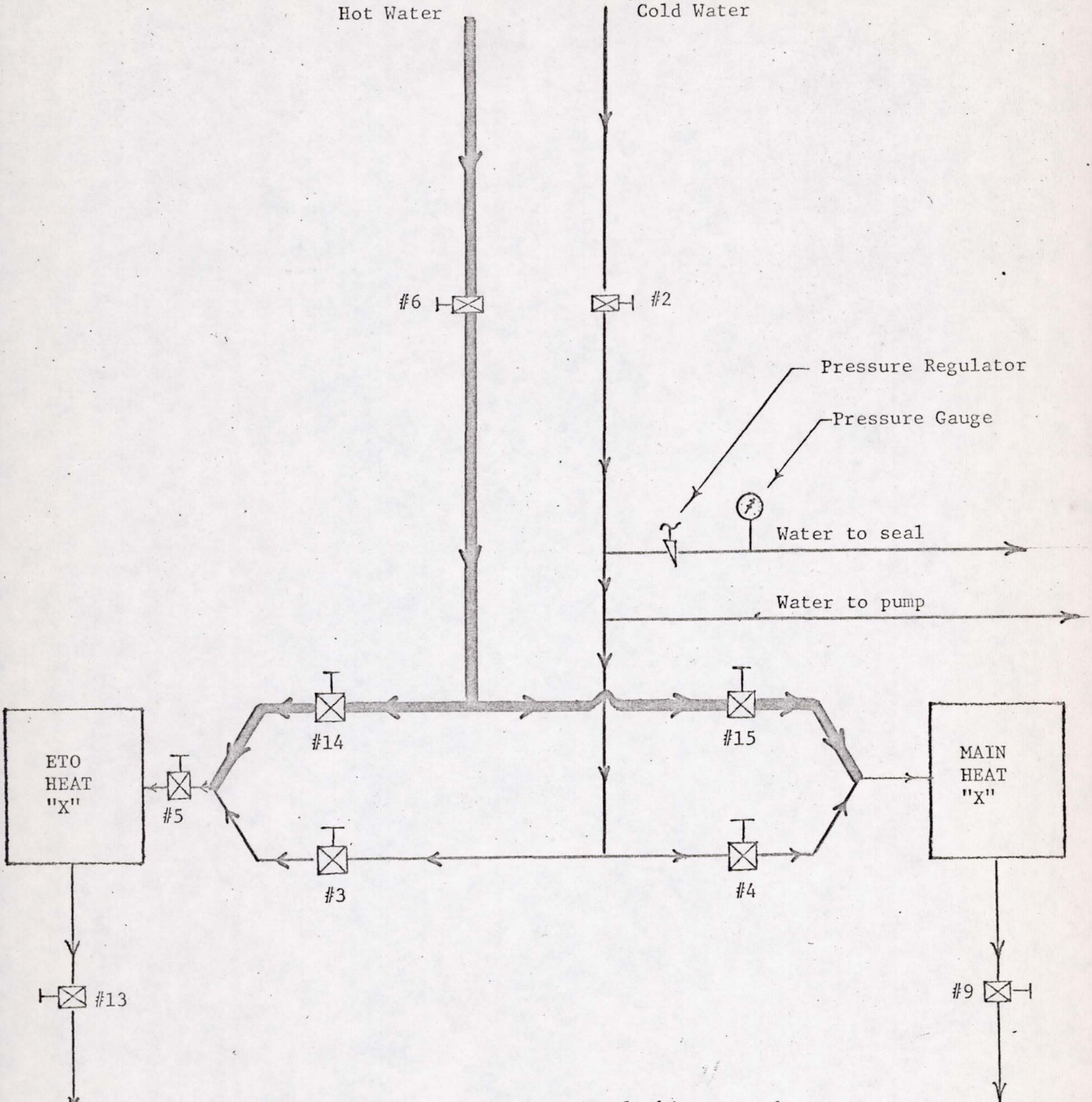
BX-5039-1177-60

HAND VALVES ON THE JPL DECONTAMINATION CHAMBER

Tagged Identification	Description & Location on Chamber
1	Steam Valve on main line supplying chamber
1A	Dead-end steam line which is no longer required - valve always closed.
1B	Removed from equipment
1C	Steam condensate valve on Humidity line
1D	Steam supply valve for Humidity line
2	Main line supplying cold water to chamber
3	Water line supplying cold water to ETO Heat Exchanger
4	Water line supplying cold water to Main Heat Exchanger
5	Modulated water supply to ETO Heat Exchanger - valve no longer required and always open
6	Main line supplying hot water to chamber
7	Between ETO Heat Exchanger and chamber; in vaporized-ETO-supply line
8	Over-pressure exhaust line following the solenoid
9	Water drain line from Main Heat Exchanger
10	Water line supplying cold water to Vacuum Pump; by-passes solenoid
11	Needle valve for controlling amount of filtered air flowing into the chamber
12	Chamber vent line
13	Water drain line from ETO Heat Exchanger
14	Water line supplying hot water to ETO Heat Exchanger
15	Water line supplying hot water to Main Heat Exchanger
16	Line connecting Drying Column to chamber
17	Line which opens the Drying Column to room air
18	Steam supply valve on Humidity-to-chamber line—above vacuum pump
Vacuum shut off	Line connecting vacuum pump to chamber
Vacuum control	Needle valve in line connecting vacuum pump to chamber

Butterfly Valves

#1	4" Interconnecting Piping at floor-exit from chamber
#2	Filtered Air inlet line - between filter and chamber
#3	Filtered Air inlet line - between filter and room air
#4	4" Interconnecting Piping at back-entrance to chamber



Schematic Diagram depicting view looking toward back end of JPL Decontamination Chamber. Primarily drawn to show various valves associated with the hot and cold water piping.

OPERATING PROCEDURES FOR THE JPL DECONTAMINATION CHAMBER

IMPORTANT PRECAUTIONARY CHECKS TO BE MADE BEFORE STARTING ANY OPERATIONS

Before starting any operations be sure of the following by inspection:

A. The following valves must be CLOSED: 1A, 2, 3, 4, 7, 8, 9, 10, 11, 12, 13, 14 15, 16, 17 & 18

B. The following valves must be OPEN: 1, 1C (partially - just enough to allow water & some steam to escape), 1D, 5 & 6

C. The four (4) Butterfly Valves must be in the following positions:
#1 & #4 - wide OPEN #2 & #3 - completely CLOSED

D. The Master Circuit Breaker on the wall must be OFF.

E. Circuit Breaker No. 1 on the Decontamination Chamber must be OFF.

F. Check the steam pressure back at the Boiler. It must be 45 psig. or above. If it is not, do not proceed with subsequent steps. Notify responsible personnel.

G. The valve on each 12:88 cylinder should be closed.

H. The Vacuum Shut-off and Vacuum Control Valves must both be tightly closed.

I. Open the stopcock located on the bottom of the Blower Housing and BE SURE there is no water at this low point before closing the stopcock again.

J. Remove the front-bottom panel from between the chamber floor and the perforated work surface and dry the chamber floor thoroughly; replace the panel.

K. Insure water FROM the Hot Water Heat Exchanger is 180°F or above.

STEPS TO BE FOLLOWED IN PREPARATION FOR STARTING THE PRECONDITIONING CYCLE

1. Load Chamber.

2. Swing door closed and insert 2 bolts at the following four (4) positions: 12 o'clock, 3 o'clock, 6 o'clock and 9 o'clock. Secure these bolts with the Electric Torque Wrench (use wall plug) in the following sequence - 12, 6, 9, & 3 o'clock. Be sure the two (2) longest bolts are saved for the hinges.

3. Insert remaining bolts and secure these with Electric Wrench in a clockwise procedure.

4. Make one complete round with Electric Torque Wrench in counter-clockwise direction to insure complete seal of chamber.

NOTE: Step #5 can be taken care of while the door is being bolted shut.

5. Make the following settings on Instrument Panel:

   a. Desired chamber pressure
   b. Desired chamber temperature
   c. Set ETO Heat Exchanger temperature to same setting as chamber temperature setting.
   d. Label and place new recording chart on vacuum-pressure-timer recorder. Insure pen has adequate ink supply.

6. Flip Master Circuit Breaker ON at wall.

7. Flip Circuit Breaker #1 on Decontamination Chamber (D.C.) ON. Be sure red light comes on. If it does not, notify responsible personnel.

8. Check steam pressure gauge on Humidity Line above the vacuum pump to insure it registers 35 psig. or above. If it does not <u>do not</u> proceed with subsequent steps. (We must have adequate pressure here to overcome any internal chamber pressure.)

9. Open cold water valve (Valve #2) located at back of D.C. above flow meter #1 all the way.

10. Check small drain line in Drain Box to insure <u>at least</u> one (1) drop per second is coming from this line (this water lubricates the seal). If not, open the needle valve controlling this flow a bit more. (No more than 3 drops/sec.)

11. Set the regulator on this line so that the pressure gauge indicates 5-8 psig.

<u>THE PRECONDITIONING CYCLE</u>

12. Turn on Circulating Fan by flipping Circulating Fan Switch ON.

13. Open cold water valve #4* which supplies cold water to the Main Heat Exchanger.

14. Open drain valve #9* until cold water flow meter #1 indicates 2 gpm.

15. Turn on LIRA; refer to MSA Instruction Book for proper procedure. (This is done at this time to provide ample time for instrument to warm up.)

16. When the "LOAD" reaches the required temperature reading, open valve 1C all the way and flush out the steam line. Then manually introduce steam to the chamber in <u>short</u> bursts by opening and closing valve 18. Continue this action until the desired relative humidity is reached in the chamber as indicated by a Bacharach or equivalent portable hygrometer viewed through one of the 8" port windows with a light shining through the other. Close 18 tightly and 1C partially.

*Proper opening procedure for ALL valves is open wide, THEN back off 1/4 turn.

17. Continue the circulation of air within the chamber for the specified period of preconditioning time. Temperature must be maintained within ±1.5°C of the desired point and %RH must be maintained within $^{+15}_{-5}$% of the desired point.

DECONTAMINATION CYCLE

18. Close cold water valve #4 after completion of preconditioning time.

19. Turn Circulating Fan Switch OFF.

20. Close drain valve #9.

21. Open hot water valve #14 and then open drain valve #13 until hot water flow meter #2 indicates 2 gpm; THEN open cold water valve #3.

22. Turn SIHI Vacuum Pump ON and IMMEDIATELY open vacuum shut-off valve; be sure water flows out of drain line leading from pump to drain box. (1.1 gpm). Control the rate of vacuum drawn, using shut-off valve and needle valve, to 2.0 psi. per minute.

23. When 15" Hg. chamber vacuum is reached, TURN VACUUM SHUT-OFF VALVE OFF; THEN IMMEDIATELY TURN OFF SIHI VACUUM PUMP. (Be sure vacuum control needle valve is closed)

24. If by chance this 15" Hg. vacuum is exceeded, then bleed air into the chamber through Mechanical Chamber Vent Valve (valve #12). BE SURE to close this valve completely following this operation.

25. Open the valve wide on the Freon 12-ETO (12:88) cylinder to be used.

26. Check temperature of water leaving the ETO Heat Exchanger to insure it is within ±10°F of the chamber temperature setting. Open mechanical gas valve to chamber (#7) just past ETO Heat Exchanger. Open the needle valve just past the Fulflow Filter and introduce 12:88 at a rate which will permit reaching the desired chamber pressure within 30±15 minutes. Set regulator on the water-line-to-seal so that pressure gauge reads 5 psig. above chamber pressure setting.

27. When desired chamber pressure is reached, 12:88 will automatically stop charging; open over-pressure mechanical valve (valve #8).

28. Close drain valve #13 and cold water valve #3.

29. Turn on Circulating Fan Switch.

30. Open cold water valve #4 and then open drain valve #9 until cold water flow meter #1 indicates 2 gpm.

31. Watch the chamber-temperature-indicator-recorder and when it indicates the desired chamber temperature has been reestablished, proceed to step 32.

32. Take a reading of the %RH inside the chamber. If %RH is too low, introduce more steam following the procedures outlined in Step #16.

33. Allow five (5) minutes to pass by for the chamber conditions to come into complete equilibrium. During this time "Zero" and "Span" the LIRA in preparation for taking a reading. Refer to MSA Instruction Book for proper procedure.

34. At the end of 5 minutes pass a sample from the chamber through the LIRA and determine the concentration in mg./liter. If it is not within $^{+50}_{-25}$ mg./liter of the desired concentration, make the necessary adjustment to the chamber pressure:

    a. If the concentration is too high bleed some pressure out of the chamber by "cracking" the vacuum shut-off valve. Be sure to close this valve again.

    b. If the concentration is too low, open Valve #13 and introduce more 12:88 following the procedures outlined in Step #26.

    NOTE: One (1) pound pressure change in the chamber will change the concentration approximately 29 mg./liter when using 12:88

    As soon as this adjustment is finished, close Valves #3 & 13 again, plus #7, the needle valve past the Fulflow filter and the valve on the 12:88 cylinder.

    Start timing the exposure period at this time
    During exposure, monitor the temperature, humidity and ETO concentration and make suitable adjustments as required.

POST DECONTAMINATION VACUUM

35. At the end of the desired exposure period turn the circulating fan switch OFF; close hot water valves 6 and 14 ; turn off the LIRA; close Drain Valve #9.

36. Close over-pressure mechanical valve (valve #8).

37. Turn SIHI Vacuum Pump ON and IMMEDIATELY open vacuum shut-off valve; be sure water flows out of drain line leading from pump to drain box (1.1 gpm). Control the <u>rate</u> of vacuum drawn, using shut-off valve and needle valve, to 2.0 psi. per minute. When the chamber pressure drops to 5 psig. set the regulator on the water-line-to-seal so that the pressure gauge reads 5-8 psig.

38. Evacuate the chamber to 28 in. Hg. vacuum (2 in. Hg. ab.). At this point, close vacuum shut-off valve <u>AND IMMEDIATELY</u> turn off SIHI Vacuum Pump. (Be sure vacuum control needle valve is closed.)

AIR WASH

39. Open Butterfly Valve #2 all the way.

40. Open Butterfly Valve #3 two (2) notches.

41. Open Needle Valve (valve #11); control the rate of chamber back-fill with this needle valve so that the chamber reaches atmospheric pressure in 45±15 minutes.

42. When atmospheric pressure is reached, slowly open Butterfly Valve #3 all the way and close needle valve #11.

43. Close Butterfly Valve #1.

44. Turn SIHI Vacuum Pump ON AND IMMEDIATELY open vacuum shut-off valve; be sure water flows out of drain line leading from pump to drain box (1.1 gpm).

45. Allow Vacuum Pump to run for ten (10) minutes.

46. Close Vacuum Shut-off Valve AND IMMEDIATELY switch off SIHI Vacuum Pump.

SECURING THE CHAMBER AFTER CYCLING

47. Open Butterfly Valve #1; close Butterfly Valves #2 and 3.

48. Open Mechanical Chamber Vent Valve (valve #12).

49. Close cold water valves 2 & 4.

50. Turn Circuit Breaker #1 off; be sure red light goes off.

51. Turn Master Circuit Breaker on wall OFF.

52. Close Steam Valves 1 & 1D and condensate valve 1C.

53. Remove bolts and open door. Remove bolts at 12, 6, 3, and 9 o'clock LAST and in that sequence.

54. Close Mechanical Chamber Vent Valve (valve #12).

NOTE: Butterfly Valve #4 is used only for controlling the velocity of atmospheric flow through the chamber.

OPERATING PROCEDURES FOR THE JPL DECONTAMINATION CHAMBER

IMPORTANT PRECAUTIONARY CHECKS TO BE MADE BEFORE STARTING ANY OPERATIONS

Before starting any operations be sure of the following by inspection:

A. The following valves must be CLOSED: 1A, 2, 3, 4, 7, 8, 9, 10, 11, 12, 13, 14 15, 16, 17 & 18

B. The following valves must be OPEN: 1, 1C (partially - just enough to allow water & some steam to escape), 1D, 5 & 6

C. The four (4) Butterfly Valves must be in the following positions:
#1 & #4 - wide OPEN #2 & #3 - completely CLOSED

D. The Master Circuit Breaker on the wall must be OFF.

E. Circuit Breaker No. 1 on the Decontamination Chamber must be OFF.

F. Check the steam pressure back at the Boiler. It must be 45 psig. or above. If it is not, do not proceed with subsequent steps. Notify responsible personnel.

G. The valve on each 12:88 cylinder should be closed.

H. The Vacuum Shut-off and Vacuum Control Valves must both be tightly closed.

I. Open the stopcock located on the bottom of the Blower Housing and BE SURE there is no water at this low point before closing the stopcock again.

J. Remove the front-bottom panel from between the chamber floor and the perforated work surface and dry the chamber floor thoroughly; replace the panel.

K. Insure water FROM the Hot Water Heat Exchanger is 180°F or above.

STEPS TO BE FOLLOWED IN PREPARATION FOR STARTING THE PRECONDITIONING CYCLE

1. Load Chamber.

2. Swing door closed and insert 2 bolts at the following four (4) positions: 12 o'clock, 3 o'clock, 6 o'clock and 9 o'clock. Secure these bolts with the Electric Torque Wrench (use wall plug) in the following sequence - 12, 6, 9, & 3 o'clock. Be sure the two (2) longest bolts are saved for the hinges.

3. Insert remaining bolts and secure these with Electric Wrench in a clockwise procedure.

4. Make one complete round with Electric Torque Wrench in counter-clockwise direction to insure complete seal of chamber.

NOTE: Step #5 can be taken care of while the door is being bolted shut.

5. Make the following settings on Instrument Panel:

   a. Desired chamber pressure
   b. Desired chamber temperature
   c. Set ETO Heat Exchanger temperature to same setting as chamber temperature setting
   d. Label and place new recording chart on vacuum-pressure-time recorder. Insure pen has adequate ink supply.

6. Flip Master Circuit Breaker ON at wall.

7. Flip Circuit Breaker #1 on Decontamination Chamber (D.C.) ON. Be sure red light comes on. If it does not, notify responsible personnel.

8. Check steam pressure gauge on Humidity Line above the vacuum pump to insure it registers 35 psig. or above. If it does not do not proceed with subsequent steps. (We must have adequate pressure here to overcome any internal chamber pressure.)

9. Open cold water valve (Valve #2)* located at back of D.C. above flow meter #1 all the way.

10. Check small drain line in Drain Box to insure at least one (1) drop per second is coming from this line (this water lubricates the seal). If not, open the needle valve controlling this flow a bit more. (No more than 3 drops/sec.)

11. Set the regulator on this line so that the pressure gauge indicates 5-8 psig.

THE PRECONDITIONING CYCLE

12. Turn on Circulating Fan by flipping Circulating Fan Switch ON.

13. Open hot water valve #15* which supplies hot water to the Main Heat Exchanger.

14. Open drain valve (Valve #9)* until hot water flow meter #2 indicates 2 gpm.

15. Turn on LIRA; refer to MSA Instruction Book for proper procedure. (This is done at this time to provide ample time for instrument to warm up.)

16. When the "Load" reaches the required temperature reading open cold water valve 4. Also open valve 1C all the way and flush out the steam line. Then manually introduce steam to the chamber in short bursts by opening and closing valve 18. Continue this action until the desired relative humidity is reached in the chamber as indicated by a Bacharach or equivalent portable hygrometer viewed through one of the 8" port windows with a light shining through the other. Close 18 tightly and 1C partially.

*Proper opening procedure for ALL valves is open wide, THEN back off 1/4 turn.

17. Continue the circulation of air within the chamber for the specified period of preconditioning time. Temperature must be maintained within ±1.5°C of the desired point and %RH must be maintained within $^{+15}_{-5}$% of the desired point.

DECONTAMINATION CYCLE

18. Close cold water valve #4 after completion of preconditioning time.

19. Turn Circulating Fan Switch OFF.

20. Close drain valve #9.

21. Open hot water valve #14 and then open drain valve #13 until hot water flow meter #2 indicates 2 gpm; THEN open cold water valve #3.

22. Turn SIHI Vacuum Pump ON and IMMEDIATELY open vacuum shut-off valve; be sure water flows out of drain line leading from pump to drain box. (1.1 gpm). Control the rate of vacuum drawn, using shut-off valve and needle valve, to 2.0 psi. per minute.

23. When 15" Hg. chamber vacuum is reached, TURN VACUUM SHUT-OFF VALVE OFF; THEN IMMEDIATELY TURN OFF SIHI VACUUM PUMP. (Be sure vacuum control needle valve is closed)

24. If by chance this 15" Hg. vacuum is exceeded, then bleed air into the chamber through Mechanical Chamber Vent Valve (valve #12). BE SURE to close this valve completely following this operation.

25. Open the valve wide on the Freon 12-ETO (12:88) cylinder to be used.

26. Check temperature of water leaving the ETO Heat Exchanger to insure it is within ±10°F of the chamber temperature setting. Open mechanical gas valve to chamber (#7) just past ETO Heat Exchanger. Open the needle valve just past the Fulflow Filter and introduce 12:88 at a rate which will permit reaching the desired chamber pressure within 30±15 minutes. Set regulator on the water-line-to-seal so that pressure gauge reads 5 psig. above chamber pressure setting.

27. When desired chamber pressure is reached, 12:88 will automatically stop charging; open over-pressure mechanical valve (valve #8).

28. Close drain valve #13 and cold water valve #3.

29. Turn on Circulating Fan Switch.

30. Open drain valve (valve #9) until hot water flow meter #2 indicates 2 gpm.

31. Watch the chamber-temperature-indicator-recorder and when it indicates the desired chamber temperature has been reestablished, open cold water valve #4.

32. Take a reading of the %RH inside the chamber. If %RH is too low, introduce more steam following the procedures outlined in Step #16.

33. Allow five (5) minutes to pass by for the chamber conditions to come into complete equilibrium. During this time "Zero" and "Span" the LIRA in preparation for taking a reading. Refer to MSA Instruction Book for proper procedure.

34. At the end of 5 minutes pass a sample from the chamber through the LIRA and determine the concentration in mg./liter. If it is not within $^{+50}_{-25}$ mg./liter of the desired concentration, make the necessary adjustment to the chamber pressure:

    a. If the concentration is too high bleed some pressure out of the chamber by "cracking" the vacuum shut-off valve. Be sure to close this valve again.

    b. If the concentration is too low, open Valve #13 and introduce more 12:88 following the procedures outlined in Step #26.

    NOTE: One (1) pound pressure change in the chamber will change the concentration approximately 29 mg./liter when using 12:88

As soon as this adjustment is finished, close Valves #3 & 13 again, plus #7, the needle valve past the Fulflow filter and the valve on the 12:88 cylinder.

Start timing the exposure period at this time
During exposure, monitor the temperature, humidity and ETO concentration and make suitable adjustments as required.

POST DECONTAMINATION VACUUM

35. At the end of the desired exposure period turn the circulating fan switch OFF; close hot water valves 6, 14 & 15; turn off the LIRA; close Drain Valve #9.

36. Close over-pressure mechanical valve (valve #8).

37. Turn SIHI Vacuum Pump ON and IMMEDIATELY open vacuum shut-off valve; be sure water flows out of drain line leading from pump to drain box (1.1 gpm). Control the rate of vacuum drawn, using shut-off valve and needle valve, to 2.0 psi. per minute. When the chamber pressure drops to 5 psig. set the regulator on the water-line-to-seal so that the pressure gauge reads 5-8 psig.

38. Evacuate the chamber to 28 in. Hg. vacuum (2 in. Hg. ab.). At this point, close vacuum shut-off valve AND IMMEDIATELY turn off SIHI Vacuum Pump. (Be sure vacuum control needle valve is closed.)

AIR WASH

39. Open Butterfly Valve #2 all the way.

40. Open Butterfly Valve #3 two (2) notches.

41. Open Needle Valve (valve #11); control the rate of chamber back-fill with this needle valve so that the chamber reaches atmospheric pressure in 45±15 minutes.

42. When atmospheric pressure is reached, slowly open Butterfly Valve #3 all the way and close needle valve #11.

43. Close Butterfly Valve #1.

44. Turn SIHI Vacuum Pump ON AND IMMEDIATELY open vacuum shut-off valve; be sure water flows out of drain line leading from pump to drain box (1.1 gpm).

45. Allow Vacuum Pump to run for ten (10) minutes.

46. Close Vacuum Shut-off Valve AND IMMEDIATELY switch off SIHI Vacuum Pump.

SECURING THE CHAMBER AFTER CYCLING

47. Open Butterfly Valve #1; close Butterfly Valves #2 and 3.

48. Open Mechanical Chamber Vent Valve (valve #12).

49. Close cold water valves 2 & 4.

50. Turn Circuit Breaker #1 off; be sure red light goes off.

51. Turn Master Circuit Breaker on wall OFF.

52. Close Steam Valves 1 & 1D and condensate valve 1C.

53. Remove bolts and open door. Remove bolts at 12, 6, 3, and 9 o'clock LAST and in that sequence.

54. Close Mechanical Chamber Vent Valve (valve #12).

NOTE: Butterfly Valve #4 is used only for controlling the velocity of atmospheric flow through the chamber.

ADDENDUM TO CHAMBER OPERATING INSTRUCTIONS

Operation of the Drying Column

In the event a cycle is planned where the relative humidity inside the chamber is HIGHER than the cycle condition desired, then the Drying Column must be used.

To operate the Drying Column in conjunction with the Decontamination Chamber:

1. Be sure Valves 16 & 17 are closed.

2. Evacuate the Decontamination Chamber to 3 in. Hg. absolute

3. TURN VACUUM SHUT-OFF VALVE OFF; THEN IMMEDIATELY TURN OFF SIHI VACUUM PUMP.

4. Open Valve 17 all the way.

5. Crack open Valve 16 and control the flow of air through the Drying Column with this valve so that the chamber absolute pressure increases at a rate not exceeding 1 in. Hg. per minute.

6. When the chamber is back to atmospheric pressure, close Valves 16 & 17.

7. a. If Relative Humidity inside the chamber is low enough, proceed with the desired cycle.
   b. If Relative Humidity inside the chamber is still too high, repeat the above procedure but increase the time required for backfilling the chamber (step 5).

According to S. Blickman, Inc. operation in accordance with these procedures will insure a <u>total</u> extraction and retention of 0.9 lbs. of water (18% of the weight of the pellets - 5 lbs.) before breakthrough, permitting approximately fifteen cycles before regeneration of the pellets is required.

To regenerate the pellets, break union connection, this will permit removal of drying column. Remove bolts holding top cover plate, remove screen, pour pellets into a tray, place tray with pellets into vented oven for one hour at temperature of 400^{o}F to 600^{o}F, permit pellets to cool, and when cool, repack the column, reversing the procedures described above.

<u>Pellets Vendor:</u> Union Carbide Corporation
Pleasant Valley Road
Moorestown, New Jersey 08057
ATTN: Mrs. Hihns Phone: 609-235-6200

<u>ORDER:</u> "X" pounds of Molecular Sieves, Type 5A, 1/8" diameter

<u>PRICE:</u> \$1.70 per pound

NOTE: minimum order accepted - \$15 (9 lbs. = \$15.30)

RESULTS

The decontamination chamber was installed at the Becton, Dickinson Research Center, Raleigh, N. C., in March, 1970. Following the initial shakedown period of approximately one month, an additional three-month period was required before the chamber was operational. Exposure of test pieces was started on June 8, 1970, after a number of chamber, control, instrument and mechanical difficulties had been corrected. Among the problems which were not resolved during the contract period were the following: reliable and functional relative humidity and temperature recorders; instrumentation for measurement of air flow; instrumentation for direct measurement of ethylene oxide concentration; development of an efficient method for alignment and securing of chamber door; replacement of the main (copper) heat exchanger with an ETO-resistant unit; resolution of the conditions that created an ethylene oxide hazard in the chamber area.

The following cycles were completed during the three-month period between June and the termination of the contract: two cycles consisting of a preconditioning (precon) phase only; two cycles consisting of a precon phase followed by a static decontamination (decon) phase; 17 cycles consisting of a precon phase followed by a dynamic decon phase (included in these cycles was the exposure of stainless steel strips previously vacuum-treated at 10^{-6} torr for 72 hours); three cycles consisting of no precon phase prior to exposure to a dynamic decon phase. In addition to the cycles described, three pre-vac/dynamic cycles were conducted in which inoculated plastic strips were subjected to a 1 hour precon phase under a 24" vacuum prior to dynamic exposure to ethylene oxide. The results of all cycles conducted are

listed in Table VIII. Pertinent physical data may be found in the same table. Tables IX through XIII show the data obtained from cycles conducted on the basis of the individual parameters investigated.

In general, all of the cycles conducted resulted in a 5 to 6 log reduction in number of viable spores. With approximately 80% of the test pieces, a small residual of viable organisms survived exposure to ethylene oxide. These residual survivors, at $10^0 - 10^3$ concentration, were present at the conclusion of nearly every cycle conducted regardless of gas concentration, exposure time, relative humidity, or temperature. The inconsistency of the data was apparent and relatively high numbers ($10^2 - 10^3$) of survivors were recovered from nearly all types of test pieces on one or more occasions. No significant patterns emerged from an analysis of the data which could have aided in explaining these results.

The most difficult test pieces to decontaminate were the capillary tubes and the Morton-capped test tubes whereas the easiest test pieces to decontaminate were the stainless steel strips. These results indicate that obstructions and geometric configuration of a test piece may play an important role in ease of decontamination. The reason for the occurrence of viable spore residuals on test pieces is not known for certain but may perhaps be due to "piling" of spores since inocula were confined to very small areas on test pieces. It is possible that a certain fraction of spores could have received some degree of protection from other overlying spores, approaching an occluded spore situation.

The most effective cycles were those conducted at 50C, 50% R.H., and 800 mg/l ethylene oxide for 16 or 24 hours. When preconditioning was carried out at atmospheric pressure, the results were equivalent to those

obtained when non-preconditioned test pieces were exposed to sterilizing conditions. Thus, in lieu of preconditioning at ambient pressure, it is possible that heated, humidified gas could be used from the onset of the cycle. Using only plastic strips, however, an apparent improvement in efficiency of inactivation was observed when the test pieces were dynamically preconditioned under a 24 inch vacuum prior to admitting ethylene oxide gas into the chamber for a 1 to 2 hour dynamic gas exposure. Due to time limitations, which permitted only three of these trials to be conducted, a definite conclusion cannot be made with respect to the relative efficiency of this type of cycle.

Of the parameters varied on the other cycles investigated, relative humidity appeared to have the most noticeable effect. Although its influence was not noticeable in the 30C and 40C cycles, the efficiency of inactivation appeared to increase when the humidity was raised from 30 to 50% during the 50C cycles.

Since only two static cycles were conducted, it is somewhat difficult to compare the results of these with the dynamic cycles conducted. However, on the basis of limited data, no advantage of one chamber condition relative to the other can be readily seen. In this regard, it would be of benefit to have further baseline data on static cycles in order to facilitate such a comparison. As mentioned above, however, a dynamic cycle preceded by dynamic preconditioning <u>under vacuum</u> appeared to give improved efficiency of inactivation. Further testing would have been of great value in determining whether this type of preconditioning treatment is indeed capable of providing better sterilizing efficiency with respect to spacecraft-type hardware.

A comparison of test pieces which had been vacuum-exposed prior to storage for three and six months revealed no significant differences in numbers of viable spores recovered when compared with non-vacuum exposed control strips. Thus, prior vacuum exposure did not appear to affect the viable microbial burden of test pieces during storage.

SUMMARY AND CONCLUSIONS

1. A decontamination chamber with the capabilities of maintaining set parameters of temperature, pressure, relative humidity, and gas concentration and which permits static or dynamic exposure of test items was designed, fabricated, and laboratory tested.

2. Test pieces of different materials, sizes, and geometric configuration were inoculated with resistant spores of *Bacillus subtilis* var. *niger* and subjected to various temperatures, exposure humidities, gas concentrations, and exposure times, with and without a preconditioning exposure at atmospheric pressure or *in vacuo*.

3. Both static and dynamic exposures of test pieces were conducted under various cycle conditions.

4. Data indicated that static and dynamic exposures were equally effective in those cycles preceded by conditioning of test pieces at atmospheric pressure. However, additional data on static cycles may have permitted a more definitive distinction to be made.

5. Of the cycles conducted as above, data indicated that those at 50C-50% R.H.-800 mg/l ETO-16 or 24 hours were the most effective in decontaminating test pieces.

6. With respect to individual parameters, the enhancement of sterilization efficiency was most apparent in the 50C cycles when relative humidity was increased from 30 to 50%.

7. Overall, the 50C cycles were more effective than the 30C to 40C cycles.

8. When the completely dynamic cycles, which included dynamic preconditioning at ambient pressure, were compared to dynamic cycles which did not include a preconditioning phase, no significant differences in efficiency of one type of cycle relative to the other were observed.

9. Dynamic preconditioning under a 24 inch vacuum followed by dynamic gas exposure apparently improved sterilizing efficiency, however, a limited number of trials precluded a definite conclusion regarding the type of cycle.

10. A small residual of viable spores remained on test pieces even when gas concentration and exposure times were increased. "Piling" of spores on test pieces with a protective effect on underlying spores may have been at least partly responsible for this occurrence.

11. Vacuum exposure of stainless steel strips for 72 hours at 10^{-6} torr prior to exposure to ETO did not result in increased inactivation of spores relative to non-vacuum treated controls.

RECOMMENDATIONS

1. An additional series of static cycles should be conducted to provide more extensive baseline data for comparison with the results of dynamic exposures.

2. More data should be obtained on dynamic cycles to prove whether this condition can provide increased efficiency of decontamination and to determine which combination(s) of parameters are the most advantageous under these conditions.

3. Further experimental work should be conducted to determine the advantage, if any, of preconditioning under vacuum immediately before introduction of ethylene oxide gas.

4. It would be highly desirable to continue the development of the chamber from an engineering viewpoint in order to incorporate fully automatic systems and controls.

5. The potential use and advantages of a dynamically operated and parametrically controlled sterilization chamber might also be investigated with respect to other gases such as formaldehyde.

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Table I. Enumeration of the *Bacillus subtilis* var. *niger* stock spore suspensions

Sample	Spore concentration (x 10^8) on indicated day			
	1	2	3	4
1	1.40	1.57	1.94	1.88
2	1.32	1.41	1.63	1.95
3	1.25	1.31	1.96	1.65
4	1.57	1.22	1.90	1.73
5	1.45	1.46	1.71	1.77
6	1.46	0.99	1.66	1.95
7	1.35	1.26	1.61	1.84
8	1.43	1.65	1.64	1.77
9	1.63	1.67	1.54	1.78
10	1.55	1.48	1.58	1.77
11	1.54	1.77	1.61	1.85
12	1.60	1.47	1.63	1.62
13	1.45	1.59	1.54	1.85
14	1.44	1.58	1.73	1.93
15	1.52	1.74	1.78	1.89
16	1.50	1.68	1.72	1.93

Table II. Ethylene oxide resistivity[d] of JPL-certified stock

Exposure time (minutes)	Microbial inactivation of various spore preparations		LD_{50}/strip[e] (minutes)	
	JPL[a]	Regular[b]	JPL	Regular
0	20/20[c]	20/20	9.25	7.25
1	20/20	20/20		
5	19/20	20/20		
10	20/20	7/20		
15	0/20	0/20		
20	0/20	0/20		
30	0/10	0/20		

a/ JPL spore strips were 7.2×10^4 spores per strip

b/ B-D manufactured strips of 7.7×10^4 spores per strip were utilized

c/ Number sterile/number exposed

d/ 125F; 50% R.H.; 1000 mg/l ethylene oxide

e/ Time required to achieve sterility on 50% of test pieces exposed

Table III. Ethylene oxide resistivity[a] of the JPL-certified spore suspension after 12 months storage at 4C

Exposure time (minutes)	Microbial inactivation[b] Number sterile/Number exposed	LD_{50}/strip (minutes)
0	15/15	
5	15/15	7.5
10	0/15	
15	0/15	
20	0/15	
30	-	

a/ 125F, 50% R.H., 1000 mg/l ETO

b/ JPL spore strips 1 x 10^5 spores/strip

Table IV. Preparation and sterilization of the JPL test pieces

Test Piece	Packaging Methods	Sterilization Methods
Morton closure test tubes (20 x 150 mm)	40 tubes per test tube rack	Dry heat at 160C for 2 hours
Open glass tubes (10 x 110 mm)	Double-wrapped in aluminum foil; 10 pcs/pkg. over-wrapped in aluminum foil	Dry heat at 160C for 2 hours
Capillary tubes (1 x 130 mm)	50 pcs/25 x 200 mm screw cap test tube. Tubes placed 40 per rack	Dry heat at 160C for 2 hours
Stainless steel strips (15 x 50 mm)	5 strips/25 x 200 mm screw cap test tube. Tubes placed 40 per rack	Dry heat at 160C for 2 hours
Plastic strips	5 strips/25 x 200 mm screw cap test tube. Tubes were places 40 per rack	Steam under pressure for 1 hour at 121C
Glass strips	5 strips/25 x 200 mm screw cap test tube. Tubes were placed 40 per rack	Dry heat at 160C for 2 hours

Table V. Spore assessment of inoculated JPL test pieces during storage

Test Piece	Viable spore concentration/test piece					
	January, 1969 inoculated test pieces			November, 1969 inoculated test pieces		
	Initial	After 3 mos.	After 6 mos.	Initial	After Vacuum	After 6 mos.
Capillary tubing	1.1×10^5	9.2×10^4	1.73×10^2	-	3.26×10^5	3.2×10^5
Glass tubing	9.4×10^5	8.7×10^5	-	6.7×10^5	4.41×10^5	1.5×10^1
Morton tubes	1.1×10^6	1.1×10^6	1.39×10^4	1.3×10^6	3.16×10^6	1.35×10^3
Glass strip	1.0×10^6	1.0×10^6	-	8.4×10^5	2.84×10^5	3.65×10^3
Plastic strip	1.2×10^6	1.1×10^6	-	8.2×10^5	2.5×10^5	1.76×10^3
Stainless steel strip	1.2×10^6	1.0×10^6	8.1×10^4	1.1×10^5	1.06×10^5	1.73×10^4

TABLE VI. - CALCULATED JPL CHAMBER PRESSURES IN PSIG.

FOR NINE (9) COMBINATIONS OF ETO CONCENTRATIONS AND CHAMBER TEMPERATURES

Chamber Temperature Setting	DESIRED CONCENTRATION		
	400 mg./1.	600 mg./1.	800 mg./1.
$30^{\circ}C$	4.84	10.90	17.00
$40^{\circ}C$	5.22	11.50	17.80
$50^{\circ}C$	5.61	12.11	18.60

NOTES:

a. All above calculations predicated on the fact that a 15 in. Hg. vacuum is first drawn on the chamber.

b. The calculated chamber pressure can be used for making the Chamber Pressure Setting on the Instrument Panel. Once the Chamber is at this pressure, the actual concentration must be verified using the LIRA.

c. One (1) pound pressure change in the chamber will change the concentration approximately 29 mg./1. when using 12:88.

TABLE VII. Performance time for one operation of the JPL chamber

Operation	Operating time (hour)
Close door	0.5
Dehumidify chamber	1.5
Equilibrate to temperature & R.H.	1.0
Precon cycle	2.5
Set up for decon	0.75
Decon cycle	4, 16 or 24
Air flushing	1.0
Open door	0.5
Unload and load chamber	0.25
Drying out of chamber	2.0

TABLE VIII. Master Chart Showing Data of all Cycles Conducted

	PARAMETRIC DATA									NUMBER OF SURVIVORS PER TEST PIECE									
	PRECONDITIONING CYCLE				DECONTAMINATION CYCLE														
(°C-% R.H.-mg/l ETO-hours)	Load Warming Phase, hrs.	R.H. Range during Precon, %	Temp. Range during Precon, °C	Length of Precon Cycle, hrs.	ETO Warming Phase, hrs.	ETO Pressure Range during Decon, psig	ETO Temp. Range during Decon, °C	R.H. Range during Decon, %	Total cycle Time, hrs.	Stainless Steel Strips	Plastic Strips	Glass Strips	Open Glass Tubes	Morton-Capped Tubes	Capillary Tubes	Vacuum Exposed S.S. Strips	Control S.S. Strips	Filter Paper Strips	Cotton Swabs
Dynamic Cycles																			
30-30-400-4	1.5	30-39	31-31	2.5	0.5	5-5	29-29.5	27-32.5	14.25							<1	<1	–	–
30-30-400-4	1.0	32-34.5	28.5-29.5	2.5	0.5	5-5	30-30.5	22-36	14.0	7.2	1.0	16.6	<1	300	1.8	–	–	–	–
30-30-600-4	1.5	24-27	30.5-31.5	2.5	0.5	11-15	30.5-32	23.5-30.5	13.5	–	–	–	–	–	–	7.3	1000	–	–
30-30-600-24	1.0	32-34	31-32	4.0	0.5	11-11	32-32.5	28-46	36.5	3.0	164	3.0	40	60	2200	3.0	1.0	–	–
30-50-600-24	2.0	45-49.5	31-31	2.5	0.75	11-11	31.5-32.5	43-55	38.0	–	–	–	–	–	–	0	<1	–	–
40-30-600-16	1.5	16-34	41-41.5	2.5	0.5	12-12	41-41.5	26-41	24.0	–	–	–	–	–	–	<1	<1	–	–
40-40-600-16	2.25	37-44	40.5-41	2.0	0.5	11.5-11.5	39-42.5	36.5-53	23.5	–	–	–	–	–	–	<1	0	–	–
40-50-600-16	1.5	45-45	40-41.5	2.5	0.5	11.75-11.75	41-41.5	43-55	21.5	–	–	–	–	–	–	1.2	0	–	–
40-40-600-24	1.0	35-40	40-40	2.5	0.5	11.75-12	39-41.5	35-51	31.0	0	157	0	2.0	5.0	590	3.0	3.0	–	–
40-40-800-16	2.0	40-40.5	39.5-40	2.5	0.75	18.5-18.5	39-40.5	40-54	21.0	12	<1	23	100	4.0	3600	9.0	3.0	–	–
40-40-800-24	1.0	38.5-40	40-41	2.5	0.75	18-18	38.5-38.5	38.5-58	31.5	4.0	640	200	3.0	4.0	24	7.0	7.0	–	–
50-30-800-4	1.75	25-25	51-52	3.0	0.67	19-19	50-52	26-36	12.0	100	10	30	150	20	5300	17	10	–	–
50-40-800-4	1.75	39-40	49.5-50.5	2.5	0.75	19.5-19.5	50-50	41.5-49.5	11.0	<1	<1	7.0	64	380	0	2.5	0	–	–
50-30-800-3*										–	–	–	–	–	–	0	0	–	–
50-50-800-16	1.6	46-47.5	50-51	2.5	1.5	19.3-19.3	50.5-50.5	47.5-58	23.0	3.0	<1	5.0	5.0	5.0	8.0	<1	10	–	–
50-50-800-24	1.3	35-44	50-51	2.5	0.5	17.5-20	46-53	36-77	32.0	–	–	–	–	–	–	0	0	–	–
50-50-800-24	1.0	45-46	49.5-51	2.0	1.25	18.75-19	50-51	44-60	31.0	7.0	3.0	7.0	0	12	1.0	8.0	3.0	–	–
Static Cycles																			
50-30-800-24	1.5	56-56	32-33.5	3.75	0.5	17.5-18	39-42.5	54-57	33.75	5.0	0	2.0	<1	0	0	–	–	–	–
30-30-400-4	1.5	41-43.5	30-31.5	2.5	0.5	5-5.5	32-38	44-49	11.5	0	15	8.0	8.0	TNTC	2.0	–	–	–	–
No Precon Phase																			
30-30-400-4	–	–	–	–	0.5	5-5	32-32	42-51	10.0	0	1.0	0	3.0	7200	0	–	–	–	–
30-30-400-4	–	–	–	–	1.5	5-5	31-32	45-54.5	9.0	0	4.3	1.8	3.0	710	0	–	–	–	–
50-50-800-24	–	–	–	–	0.5	19.5-19.5	50.5-51	41-61	28.5	<1	3.0	2.0	0	0	2.0	–	–	–	–
Precon Phase Only																			
40C - 50% R.H.	1.0	48-53	40-42.5	3.0	–	–	–	–	7.0	1.28×10^6	–	–	–	1.0×10^5	–	–	–	–	–
50C - 50% R.H.	1.0	45-52	51-52	3.0	–	–	–	–	6.0	1.49×10^6	–	–	–	8.8×10^5	–	–	–	–	–
Vacuum Precon/Dynamic																			
50-50-400-1	0.67	44-46	40-42	0.25					4.67	–	0	–	–	–	–	–	–	–	–
50-50-400-2	1.67	41-51	32-42	1.0	0.25	1-1.5	43-50	46-50	8.0	–	2.0	–	–	–	–	–	–	–	–
50-50-400-2	1.0	44-47	38-43.5	1.0	0.17	1.3-1.5	45-51	43-45	8.0	–	9.0	–	–	–	–	–	–	–	–
Spores in 80% Methanol																			
30-30-400-4	2.0	40-45	28.5-30	2.5	0.5	5-5	29-31.5	43-51	12.0	<1	0	1.2	0	5.2	2.6	–	–	<1	1.3

*Data misplaced

TABLE IX. A Comparison of all Cycles[1] on the Basis of Temperature

Temperature °C	Other Parameters	NUMBER OF SURVIVORS[3] PER TEST PIECE					
		Stainless Steel Strips	Plastic Strips	Glass Strips	Glass Tubes	Morton-Capped Tubes	Capillary Tubes
30	No precon						
	30-400-4[2]	0	1.0	0	3.0	7200	0
	30-400-4	0	4.3	1.8	3.0	710	0
	Static						
	30-400-4	0	15	8.0	80	TNTC	2.0
	Dynamic						
	30-400-4	7.2	1.0	16.6	<1	300	1.8
	30-600-24	3.0	164	3.0	40	60	2200
	Spores in 80% Methanol						
	30-400-4	<1	0	1.2	0	5.2	2.6
40	Precon only						
	50% R.H.	1.49×10^6	-	-	-	8.8×10^5	-
	Dynamic						
	40-600-24	0	157	0	2.0	5.0	590
	40-800-24	4.0	640	200	3.0	4.0	24
	40-800-16	12	<1	23	100	4.0	3600
50	Precon only						
	50% R.H.	1.28×10^6	-	-	-	1.0×10^5	-
	Dynamic						
	30-800-4	100	10	30	150	20	5300
	40-800-4	<1	<1	7.0	64	380	0
	50-800-16	3.0	<1	5.0	5.0	5.0	8.0
	50-800-24	7.0	3.0	7.0	0	12	1.0
	No precon						
	50-800-24	<1	3.0	2.0	0	0	2.0
	Static						
	50-800-24	5.0	0	2.0	<1	0	0

[1] Except those in which stainless steel strips were exposed to 10^{-7} torr vacuum for 72 hours prior to ETO exposure.

[2] Percent relative humidity, mg ETO/1, and exposure time in hours, in order.

[3] *Bacillus subtilis* var. *niger* spores.

TABLE X. A Comparison of all Cycles[1] on the Basis of Relative Humidity

Percent Relative Humidity	Other Parameters	NUMBER OF SURVIVORS[3] PER TEST PIECE					
		Stainless Steel Strips	Plastic Strips	Glass Strips	Glass Tubes	Morton-Capped Tubes	Capillary Tubes
	No precon						
30	30-400-4[2]	0	1.0	0	3.0	7200	0
	30-400-4	0	4.3	1.8	3.0	710	0
	Static						
	30-400-4	0	15	8.0	80	TNTC	2.0
	Dynamic						
	30-400-4	7.2	1.0	16.6	<1	300	1.8
	30-600-24	3.0	164	3.0	40	60	2200
	50-800-4	100	10	30	150	20	5300
	Spores in 80% Methanol						
	30-400-4	<1	0	1.2	0	5.2	2.6
	Dynamic						
40	40-600-24	0	157	0	2.0	5.0	590
	40-800-24	4.0	640	200	3.0	4.0	24
	40-800-16	12	<1	23	100	4.0	3600
	50-800-4	<1	<1	7.0	64	380	0
	Precon only						
50	40C	1.49×10^6	-	-	-	1.0×10^5	-
	50C	1.28×10^6	-	-	-	8.8×10^5	-
	No precon						
	50-800-24	<1	3.0	2.0	0	0	2.0
	Static						
	50-800-24	5.0	0	2.0	<1	0	0
	Dynamic						
	50-800-16	3.0	<1	5.0	5.0	5.0	8.0
	50-800-24	7.0	3.0	7.0	0	12	1.0

[1] Except those in which stainless steel strips were exposed to 10^{-7} torr vacuum for 72 hours prior to ETO exposure.

[2] Degrees centigrade, mg ETO/1, and exposure time in hours, in order.

[3] *Bacillus subtilis* var. *niger* spores.

TABLE XI. A Comparison of all Cycles[1] on the Basis of Ethylene Oxide Concentration

Ethylene Oxide Concentration mg/1	Other Parameters	NUMBER OF SURVIVORS[3] PER TEST PIECE					
		Stainless Steel Strips	Plastic Strips	Glass Strips	Glass Tubes	Morton-Capped Tubes	Capillary Tubes
400	No precon						
	30-30-4[2]	0	1.0	0	3.0	7200	0
	30-30-4	0	4.3	1.8	3.0	710	0
	Static						
	30-30-4	0	15	8.0	80	TNTC	2.0
	Dynamic						
	30-30-4	7.2	1.0	16.6	<1	300	1.8
	Spores in 80% Methanol						
	30-30-4	<1	0	1.2	0	5.2	2.6
600	Dynamic						
	30-30-24	3.0	164	3.0	40	60	2200
	40-40-24	0	157	0	2.0	5.0	590
800	No precon						
	50-50-24	<1	3.0	2.0	0	0	2.0
	Static						
	50-50-24	5.0	0	2.0	<1	0	0
	Dynamic						
	40-40-24	4.0	640	200	3.0	4.0	24
	40-40-16	12	<1	23	100	4.0	3600
	50-30-4	100	10	30	150	20	5300
	50-40-4	<1	<1	7.0	64	380	0
	50-50-16	3.0	<1	5.0	5.0	5.0	8.0
	50-50-24	7.0	3.0	7.0	0	12	1.0

1/ Except those in which stainless steel strips were exposed to 10^{-7} torr vacuum for 72 hours prior to ETO exposure.

2/ Degrees centigrade, percent relative humidity, and exposure time in hours, in order.

3/ *Bacillus subtilis* var. *niger* spores

TABLE XII. A Comparison of all Cycles[1] on the Basis of Exposure Time

Exposure Time (hrs.)	Other Parameters	NUMBER OF SURVIVORS[3] PER TEST PIECE					
		Stainless Steel Strips	Plastic Strips	Glass Strips	Glass Tubes	Morton-Capped Tubes	Capillary Tubes
4	No precon						
	30-30-400[2]	0	1.0	0	3.0	7200	0
	30-30-400	0	4.3	1.8	3.0	710	0
	Static						
	30-30-400	0	15	8.0	80	TNTC	2.0
	Dynamic						
	30-30-400	7.2	1.0	16.6	<1	300	1.8
	50-30-800	100	10	30	150	20	5300
	50-40-800	<1	<1	7.0	64	380	0
	Spores in 80% Methanol						
	30-30-400	<1	0	1.2	0	5.2	2.6
16	Dynamic						
	40-40-800	12	<1	23	100	4.0	3600
	50-50-800	3	<1	5.0	5.0	5.0	8.0
24	No precon						
	50-50-800	<1	3.0	2.0	0	0	2.0
	Static						
	50-50-800	5.0	0	2.0	<1	0	0
	Dynamic						
	30-30-600	3.0	164	3.0	40	60	2220
	40-40-600	0	157	0	2.0	5.0	590
	40-40-800	4	640	200	3.0	4.0	24
	50-50-800	7.0	3.0	7.0	0	12	1.0

[1] Except those in which stainless steel strips were exposed to 10^{-7} torr vacuum for 72 hours prior to ETO exposure.

[2] Degrees centigrade, percent relative humidity, and mg ETO/1, in order.

[3] *Bacillus subtilis* var. *niger* spores.

TABLE XIII. A Comparison of Static and Dynamic Cycles[1/]

Type of cycle	Parameters	NUMBER OF SURVIVORS[3/] PER TEST PIECE					
		Stainless Steel Strips	Plastic Strips	Glass Strips	Glass Tubes	Morton-Capped Tubes	Capillary Tubes
Static	30-30-400-4[2/]	0	15	8.0	80	TNTC	2.0
	50-50-800-24	5.0	0	2.0	<1	0	0
Dynamic	30-30-400-4	7.2	1.0	16.6	<1	300	1.8
	30-30-600-24	3.0	164	3.0	40	60	2220
	40-40-800-16	12	<1	23	100	4.0	3600
	40-40-600-24	0	157	0	2.0	5.0	590
	40-40-800-24	4.0	640	200	3.0	4.0	24
	50-30-800-4	100	10	30	150	20	5300
	50-40-800-4	<1	<1	7.0	64	380	0
	50-50-800-16	3.0	<1	5.0	5.0	5.0	8.0
	50-50-800-24	7.0	3.0	7.0	0	12	1.0
	No precon						
	30-30-400-4	0	1.0	0	3.0	7200	0
	30-30-400-4	0	4.3	1.8	3.0	710	0
	50-50-800-24	<1	3.0	2.0	0	0	2.0
	Spores in 80% Methanol						
	30-30-400-4	<1	0	1.2	0	5.2	2.6

[1/]Except those in which stainless steel strips were exposed to 10^{-7} torr vacuum for 72 hours prior to ETO exposure.

[2/]Degrees centigrade, percent relative humidity, mg ETO/1, and exposure in hours, in order.

[3/]*Bacillus subtilis* var. *niger* spores.

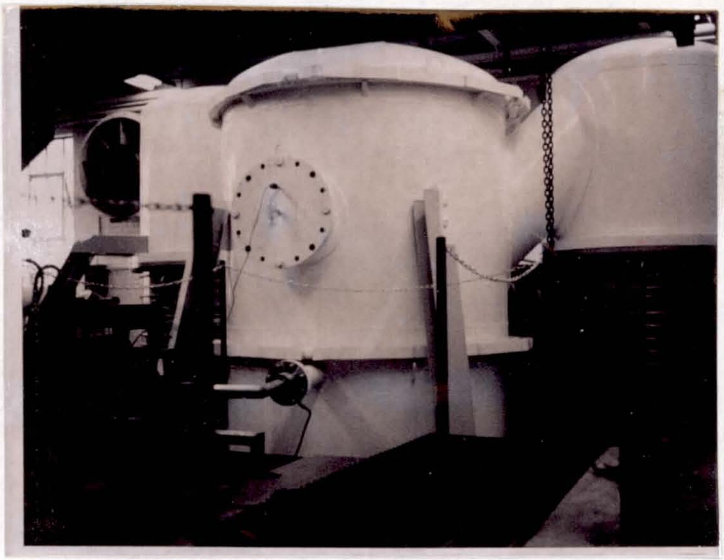


Figure 1

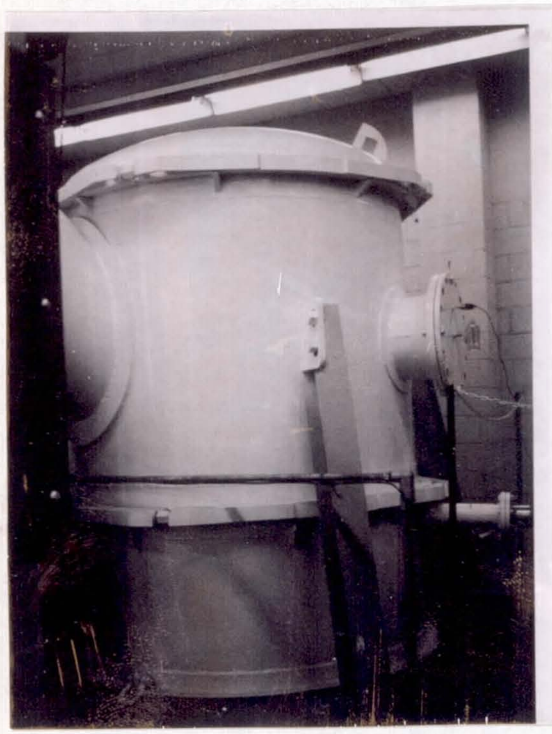


Figure 2

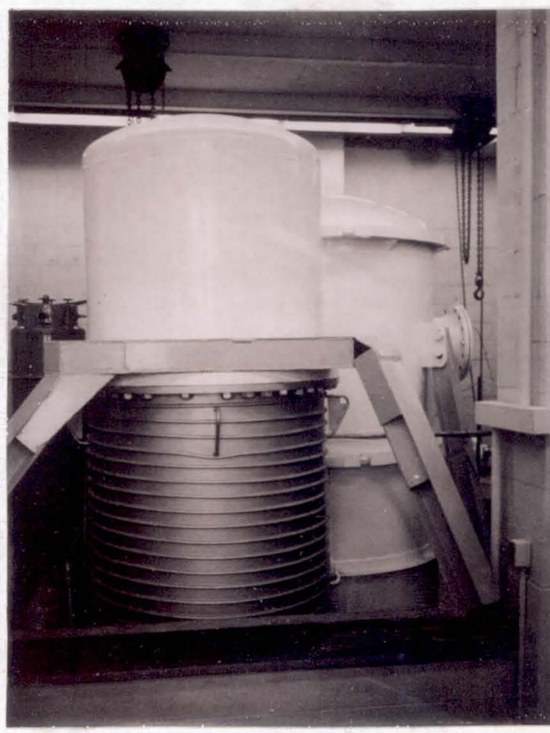


Figure 3

Vacuum exposure chamber with auxiliary diffusion pumps, located at North Carolina State University

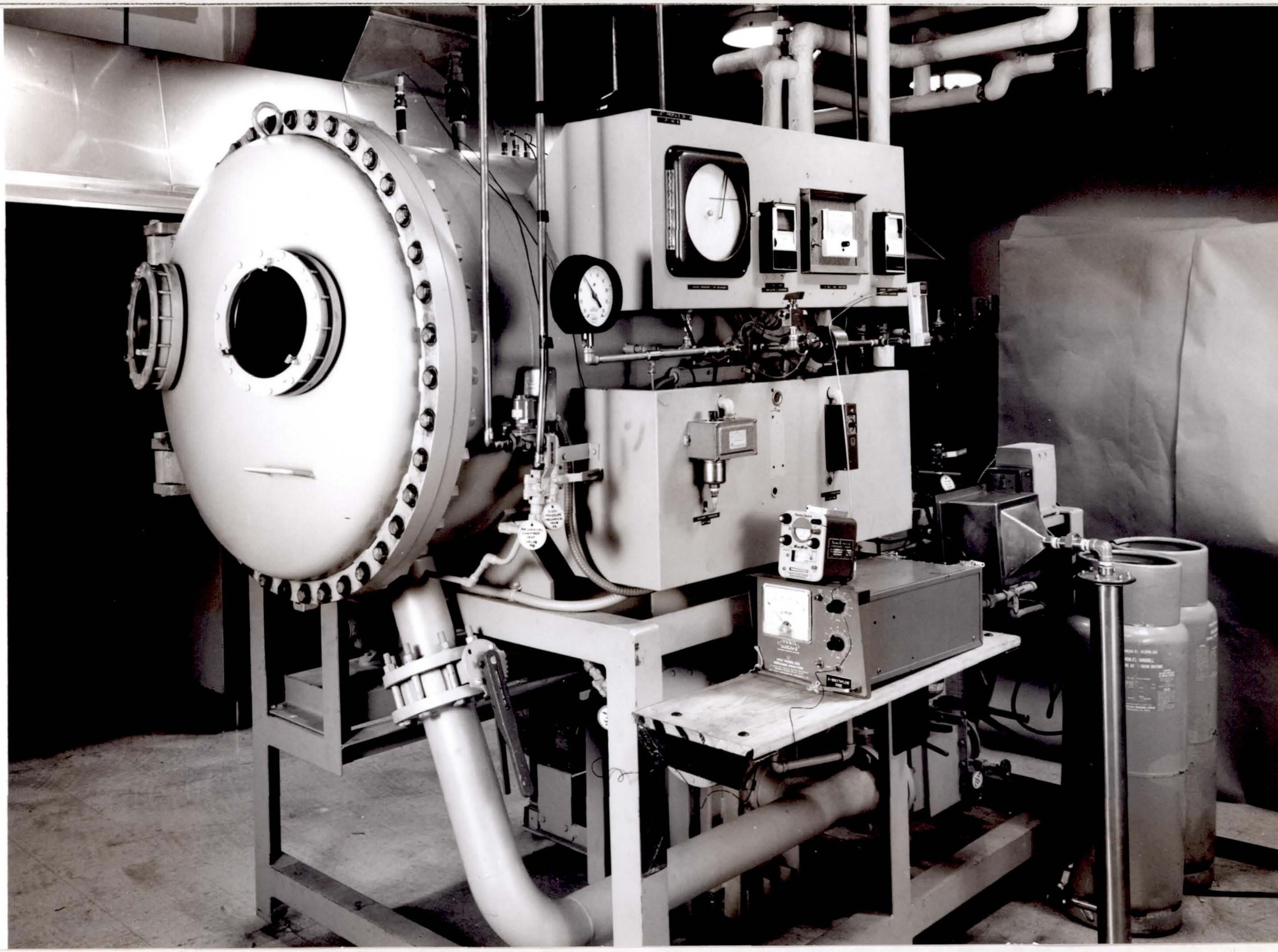


Figure 4

An overall view of the right side of the decontamination chamber showing view ports, instrument panel, and ethylene oxide cylinders.

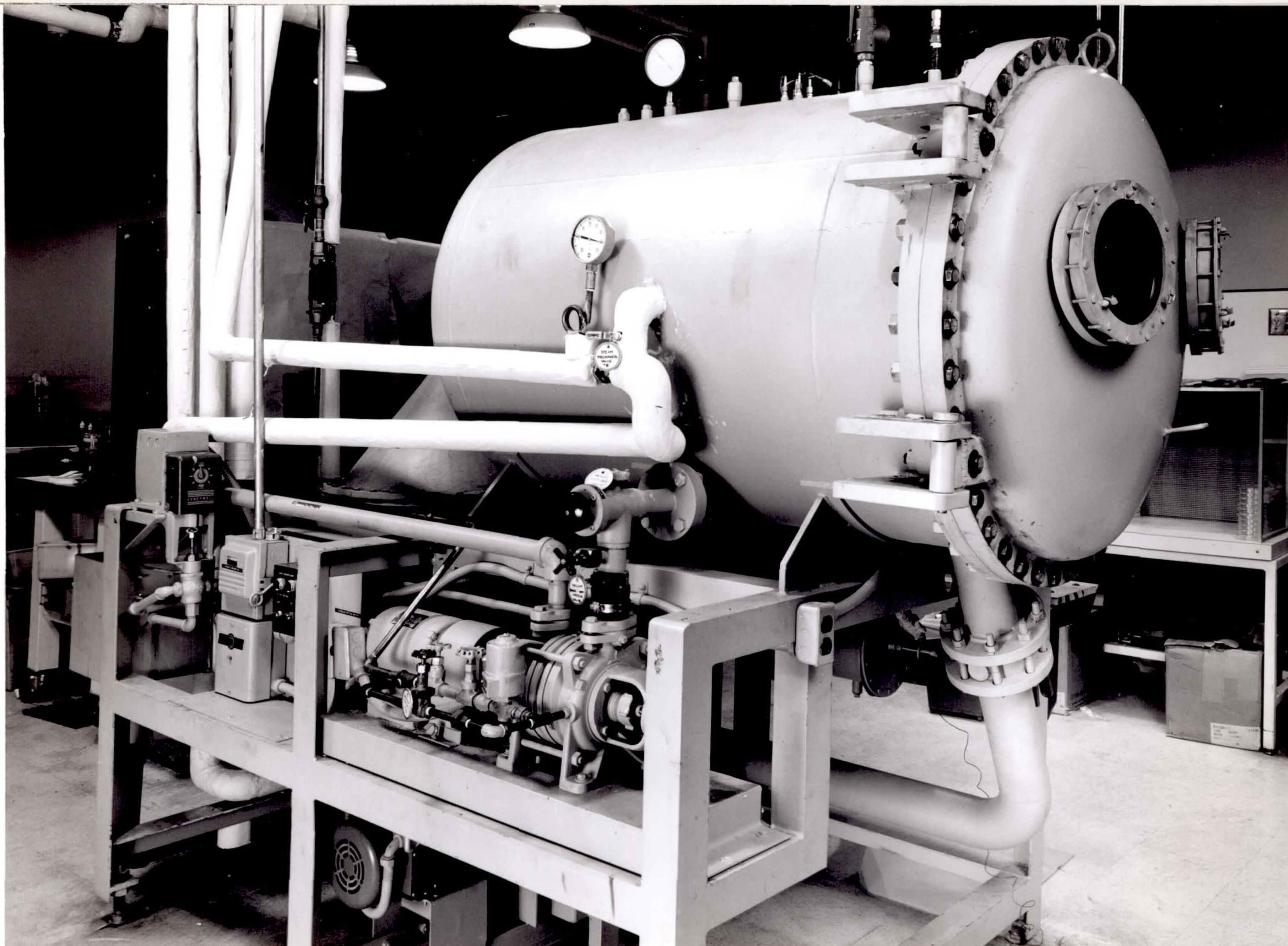


Figure 5

An overall view of the left side of the decontamination chamber showing steam injection pipes, vacuum system, modutrol assembly for main heat exchanger.

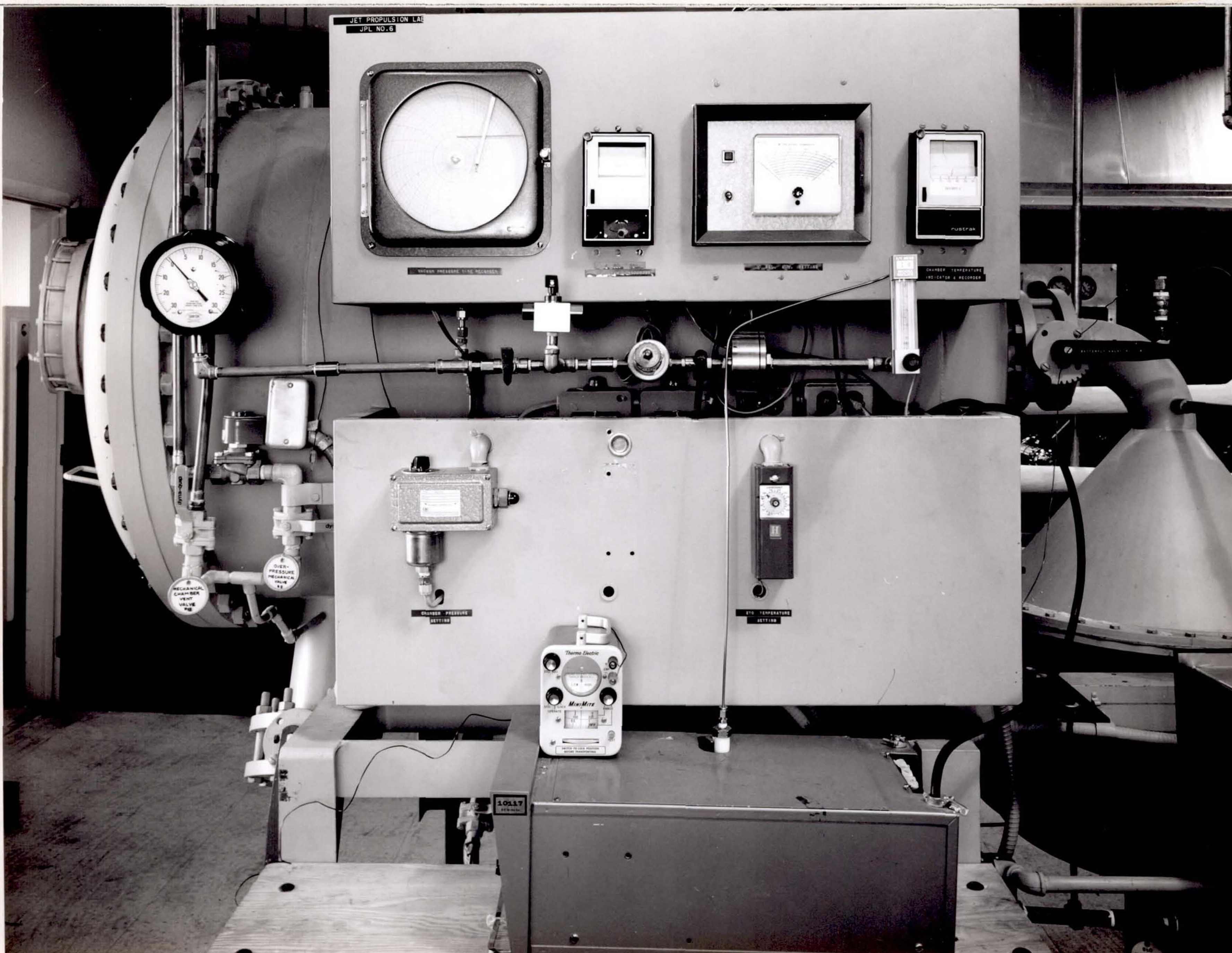


Figure 6

View of instrumentation panel showing temperature and pressure controls and recorders, LIRA and potentiometer.

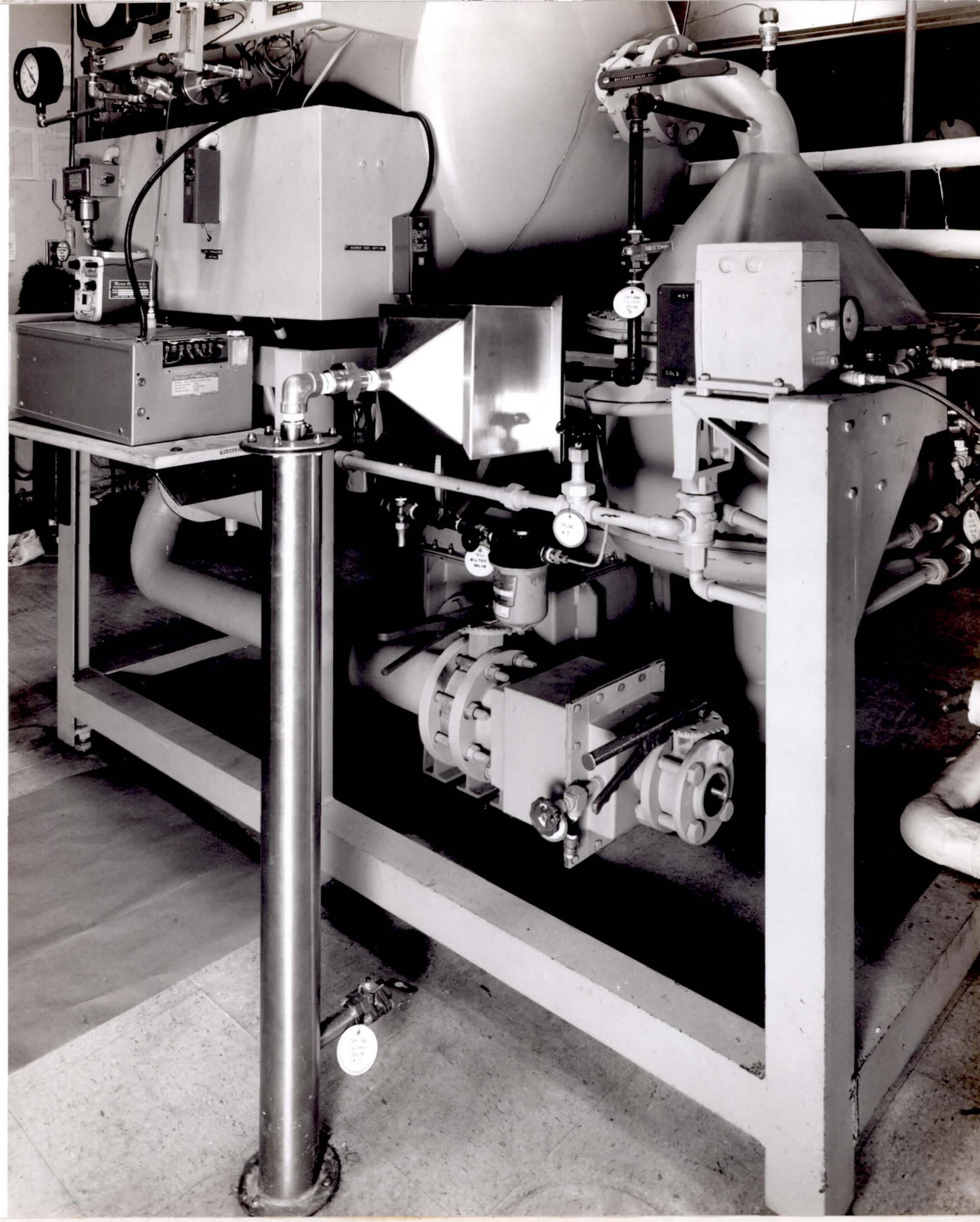
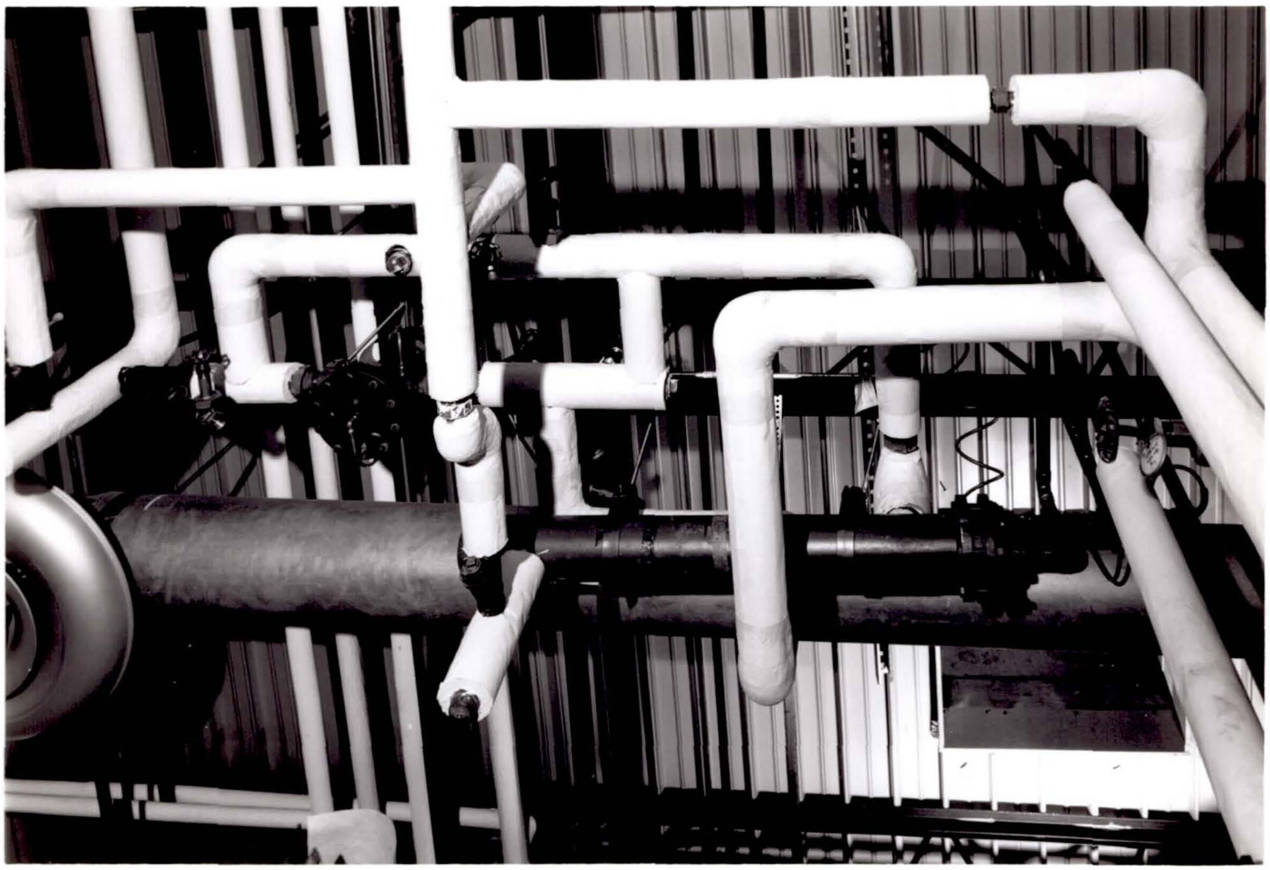


Figure 7

View showing drying column and filter; absolute filter housing and inlet; and ethylene oxide heat exchanger and filter.

Figure 8

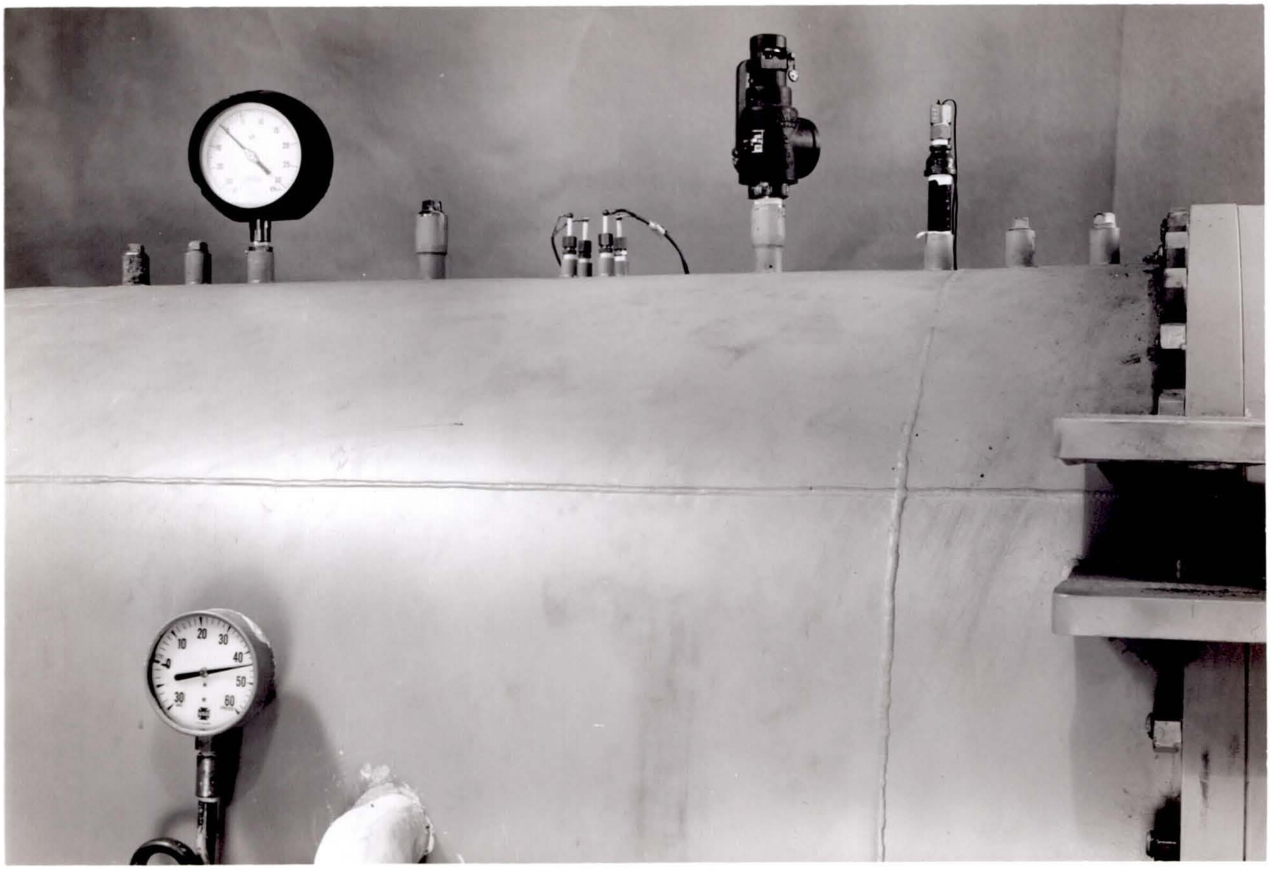


A view showing the overhead hot water heater.

Figure 9

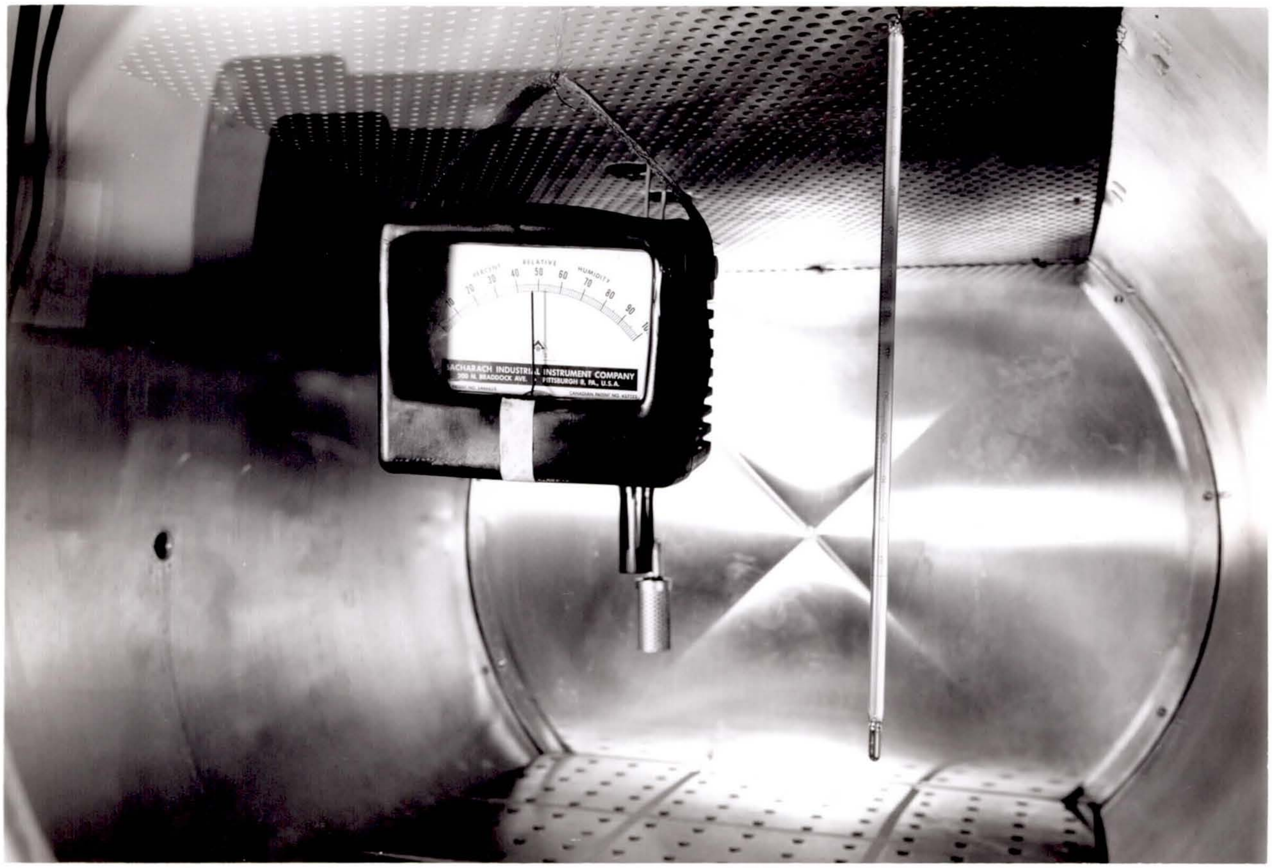
Rear view of chamber showing hot and cold water piping with control and inlet valves and drain box.

Figure 10



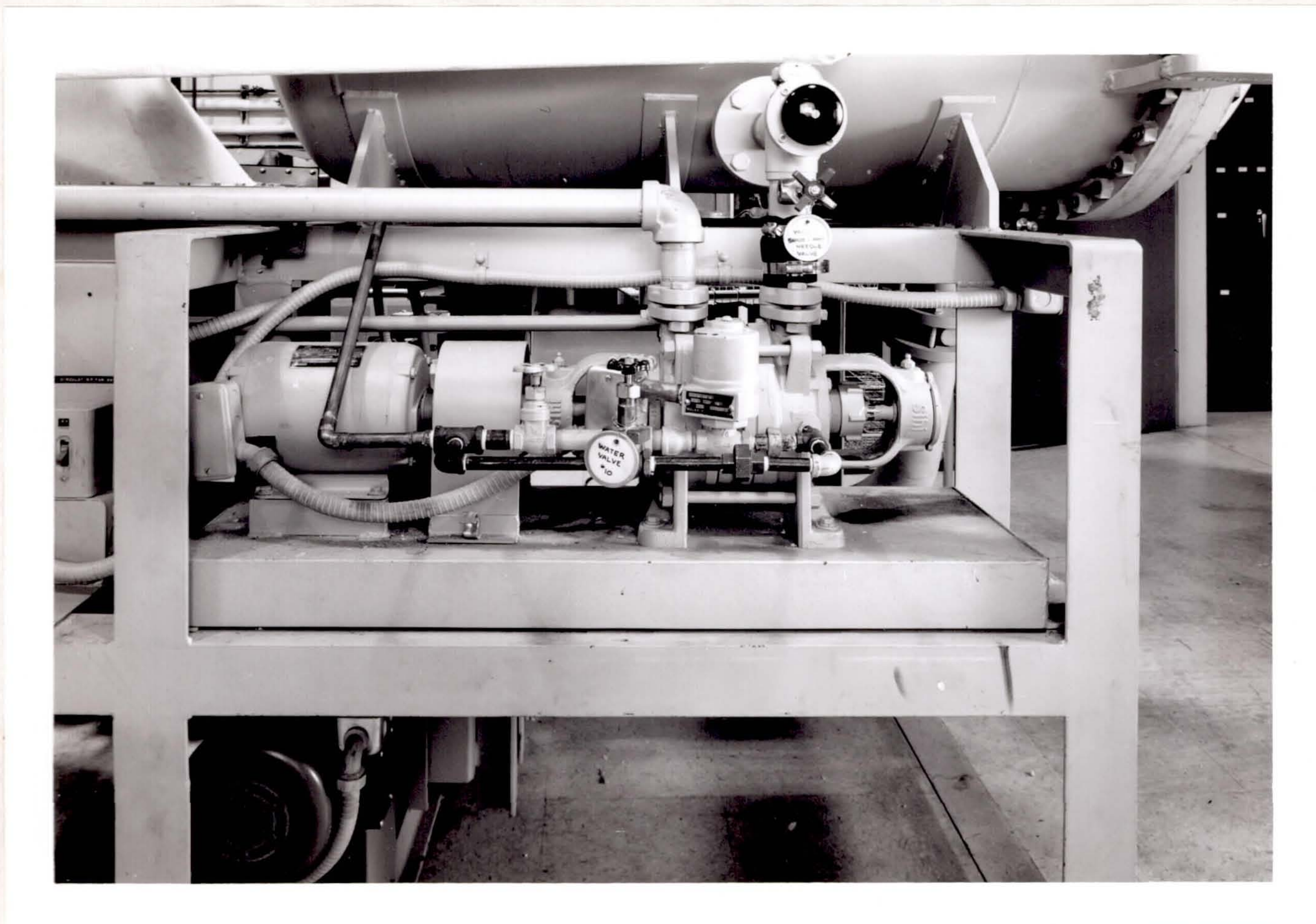
Top surface of chamber showing pressure gauge and over-pressure relief valve.

Figure 11



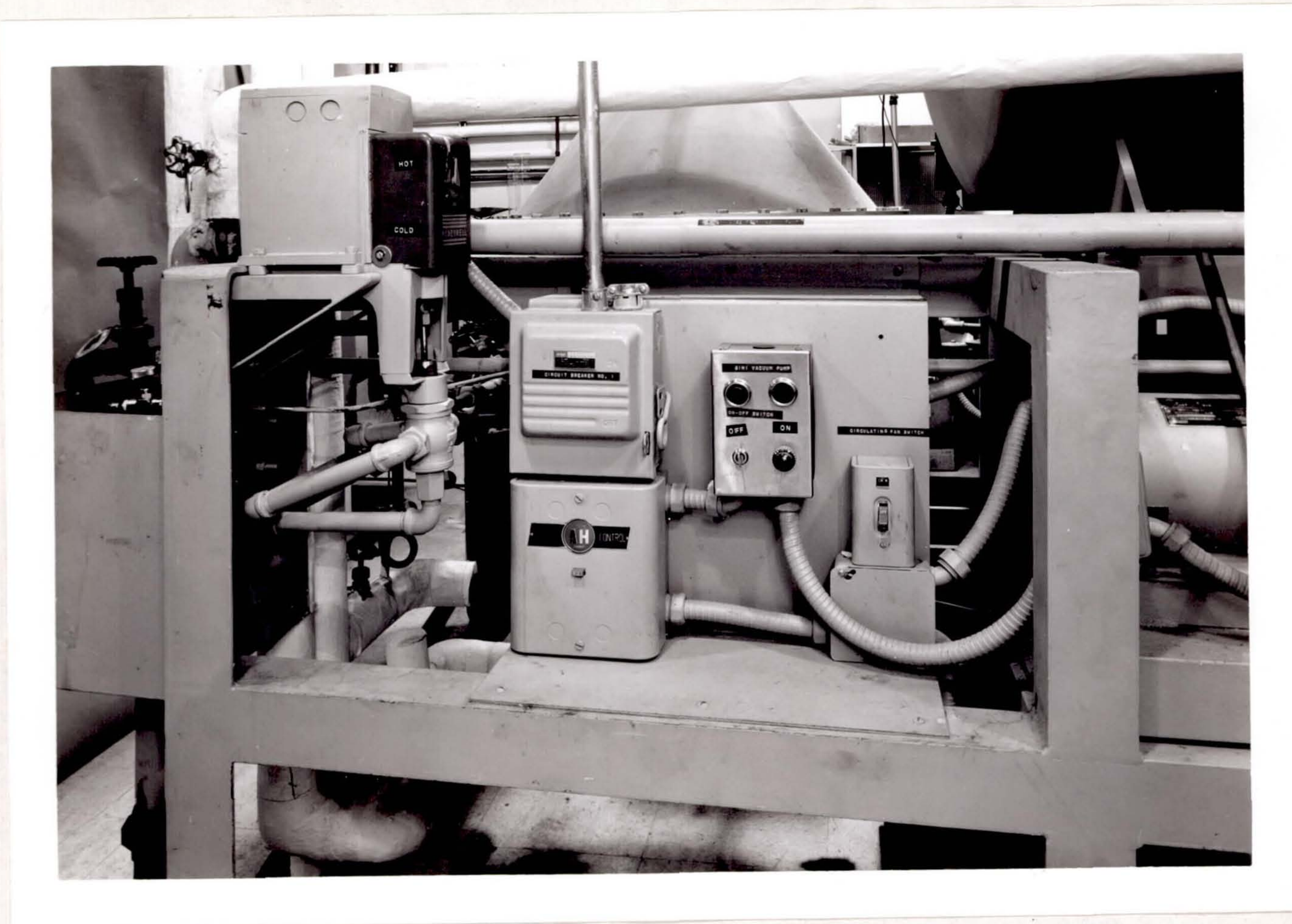
View of inside of chamber showing perforated ceiling and work surface, thermometer, and relative humidity sensor.

Figure 12



Close-up view of vacuum system.

Figure 13



Close-up view of control switches showing circuit breaker, vacuum pump switch, circulating fan switch.

APPENDIX

TABLE I. Initial evaluation of Branson sonic apparatus

TOP VIEW--LOCATION OF POSITIONS

Drain	1	2	3	4	5	
	6	7	8	9	10	
	11	12	13	14	15	
	16	17	18	19	20	) Plug

Each position represents 4 square inches

Drain	1 100	2 69	3 90	4 76	5 17	
	6 100	7 100	8 100	8 73	9 87	
	11 80	12 91	13 -	14 77	15 23	
	16 80	17 73	18 71	19 70	20 73	) Plug

Position / % Recovery (Biologically assessed)

Each position represents average percent recovery of two runs

Mean recovery: 76%

TABLE II. Assessment of spore recovery at 10 locations in the Branson sonic apparatus

Position	Percent Spore Recovery
1-6	70
2-7	-*
3-8	-*
4-9	63
5-10	62
11-16	100
12-17	100
13-18	100
14-19	100
15-20	100

*Not done

Table III. Recovery effects of Tween 80 in TSB during sonication

Run Number	Viable spore concentration recovered/strip		
	TSB - Plain	TSB with 0.5% Tween 80	Inoculum Control
1	1.3×10^5	2.1×10^5	1.5×10^5
2	2.8×10^4	4.9×10^5	
3	5.4×10^4	2.8×10^5	
4	5.4×10^3	3.2×10^5	
5	1.4×10^5	6.0×10^5	
6	8.9×10^4	1.6×10^5	
7	1.4×10^5	5.2×10^5	
Average	8.4×10^3	3.8×10^5	

CALCULATIONS FOR JPL CHAMBER PRESSURES

(psig) REQUIRED FOR DESIRED ETO CONCENTRATIONS

At Standard Temperature and Pressure

Co in milligrams per liter (mg/l) equals:

$$\frac{\text{wt.\%ETO} \times \text{MW of mixture}}{22.4 \times 10^{-1}} = \frac{12 \times 100}{22.4 \times 10^{-1}} = 536$$

At Sterilizer Conditions

$$C = Co \times \frac{P}{Po} \times \frac{To}{T}$$

Where:

$Po = 14.7$ psia
$To = 492°R$
$T = 460 + °F$
$P = (\frac{\text{in. Hg. vac}}{30} \times 14.7) + \text{psig}$

Therefore:

$$C = 536 \times \frac{P}{14.7} \times \frac{492}{T} = 17{,}939.6\ \frac{P}{T}$$

Assuming C we solve for P:

$$P = \frac{CT}{17{,}939.6}$$

Solving for psig:

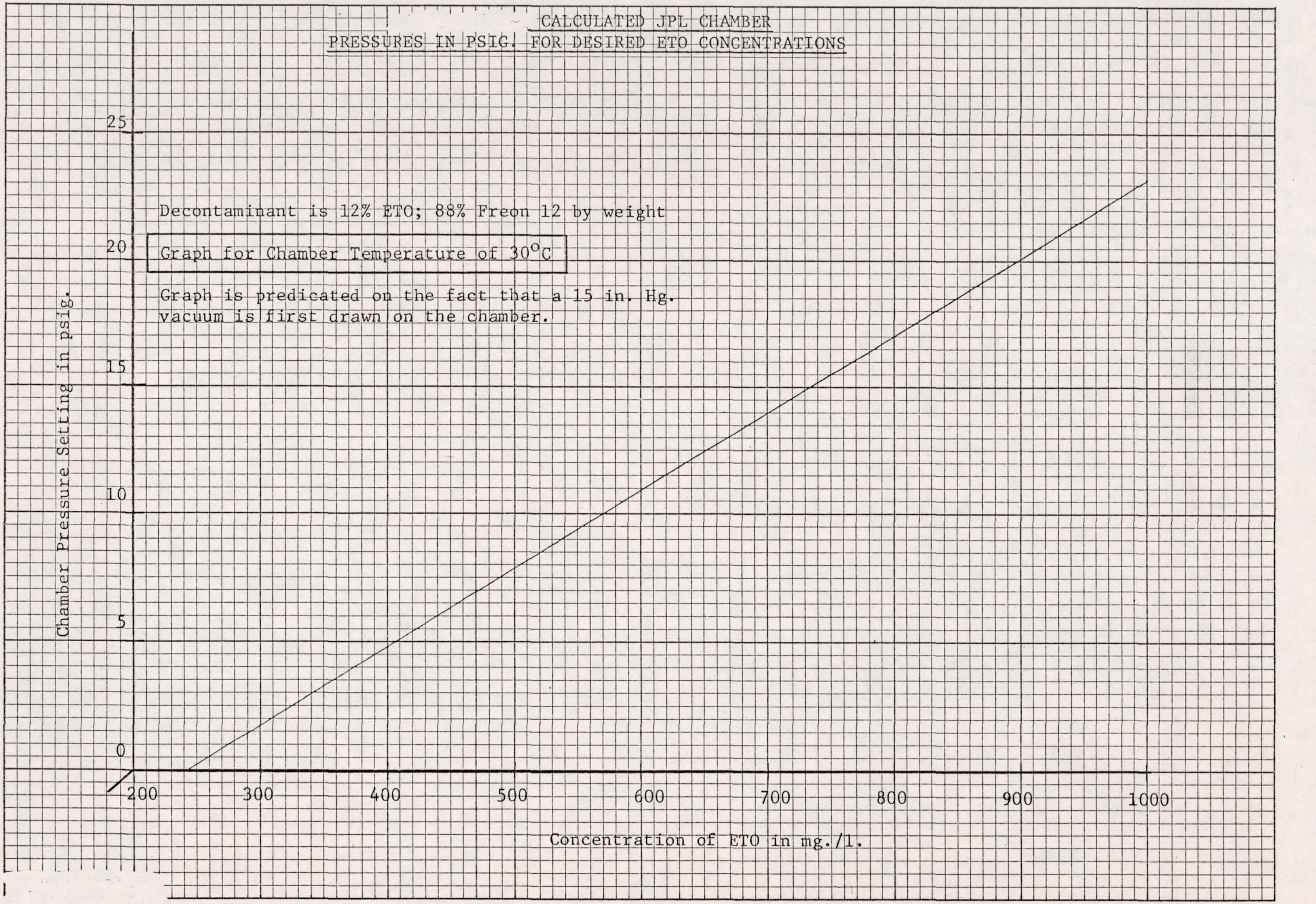
$$\text{psig} = P - (\frac{\text{in. Hg. vac.}}{30} \times 14.7)$$

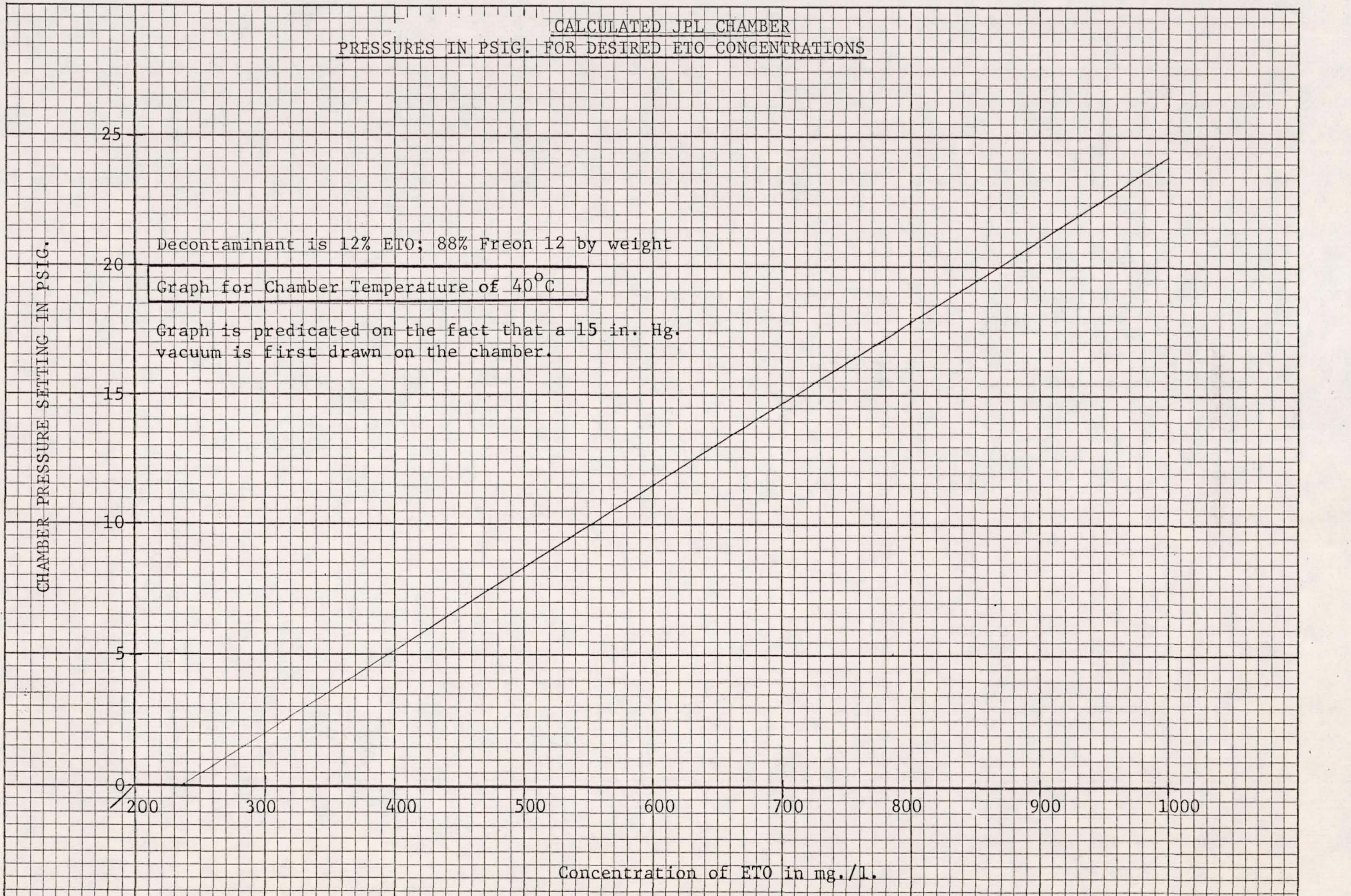
For the three (3) temperatures selected "T" equals:

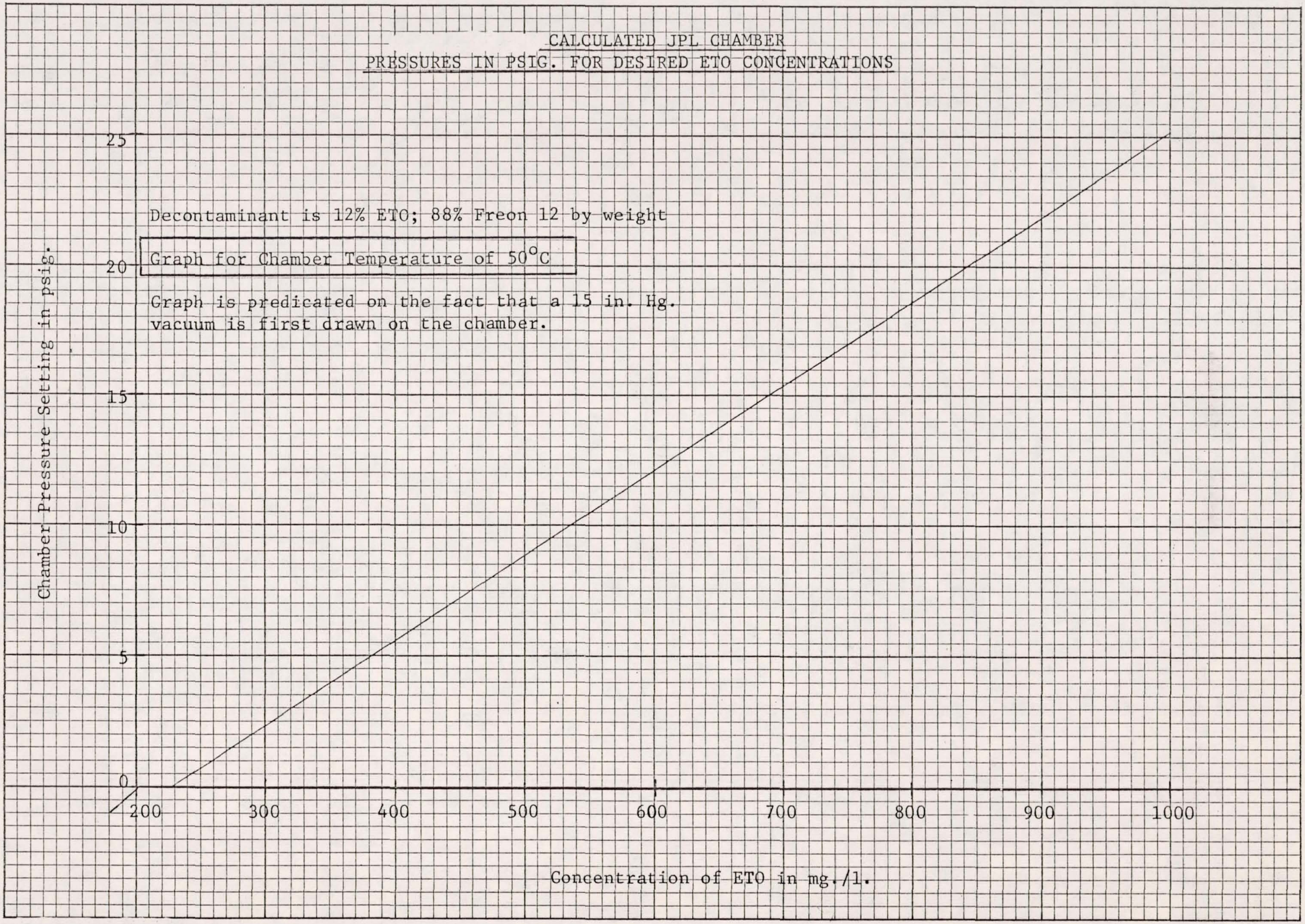
30°C $T = 460 + 86 = 546$
40°C $T = 460 + 104 = 564$
50°C $T = 460 + 122 = 582$

It is now just a matter of substituting the three (3) concentrations desired in combination with the three (3) temperatures selected.

These equations were used in preparing the following graphs.


CALCULATED JPL CHAMBER
PRESSURES IN PSIG. FOR DESIRED ETO CONCENTRATIONS
Decontaminant is 12% ETO; 88% Freon 12 by weight
Graph for Chamber Temperature of 30°C
Graph is predicated on the fact that a 15 in. Hg. vacuum is first drawn on the chamber.
Chamber Pressure Setting in psig.
25
20
15
10
5
0
200
300
400
500
600
700
800
900
1000
Concentration of ETO in mg./l.


CALCULATED JPL CHAMBER
PRESSURES IN PSIG. FOR DESIRED ETO CONCENTRATIONS
Decontaminant is 12% ETO; 88% Freon 12 by weight
Graph for Chamber Temperature of 40°C
Graph is predicated on the fact that a 15 in. Hg. vacuum is first drawn on the chamber.
CHAMBER PRESSURE SETTING IN PSIG.
25
20
15
10
5
0
200
300
400
500
600
700
800
900
1000
Concentration of ETO in mg./l.


CALCULATED JPL CHAMBER
PRESSURES IN PSIG. FOR DESIRED ETO CONCENTRATIONS
Decontaminant is 12% ETO; 88% Freon 12 by weight
Graph for Chamber Temperature of 50°C
Graph is predicated on the fact that a 15 in. Hg. vacuum is first drawn on the chamber.
Chamber Pressure Setting in psig.
25
20
15
10
5
0
200
300
400
500
600
700
800
900
1000
Concentration of ETO in mg./l.

TEST PLAN

PHASE I

CONTRACT: The Development of Parametric Data for the Establishment of an Ethylene Oxide Cycle for the Decontamination of Spacecraft

CONTRACT NO: 952169

FOR: The Jet Propulsion Laboratory
California Institute of Technology
4800 Oak Grove Drive
Pasadena, California 91103

SUBMITTED BY: Becton, Dickinson and Company
Rutherford, New Jersey 07070

DATE SUBMITTED: October 15, 1968

PRINCIPAL INVESTIGATORS: Dr. G. Briggs Phillips
Dr. Jerry J. Tulis

I. PREPARATION AND CERTIFICATION OF BACILLUS SUBTILIS VAR NIGER SPORES

Preparation of Stock Culture

Approximately 400 ml of a suspension of Bacillus subtilis var niger spores will be prepared, starting with Fort Detrick lyophilized material. The count of this suspension is to be between 1×10^9 and 1×10^{10} organisms per ml. A sufficient quantity of dry material will be weighed out and aseptically placed in sterile distilled water and held at $3° \pm 2°C$ for 48 hours. The cold water suspension will then be centrifuged, re-suspended and re-centrifuged a total of five times. The resulting stock suspension will be stained and examined for per cent spores and extraneous cellular debris. If necessary, further purification methods will be employed, including enzyme digestion. When the suspension is acceptable from the point of view of per cent spores and freedom from debris, the final stock suspension (stock culture) will be adjusted to contain approximately 1×10^9 viable organisms per ml. This stock suspension will be diluted 1:10 in sterile distilled water (count of 1×10^8 per ml) and placed in sterile sealed bottles in 50 ml quantities (approximately 80 bottles total). These containers will be placed in a water bath for 20 minutes at a temperature of 80°C. Additional plate counts will be made on at least 10 of these bottles that are to be used first in conjunction with this contract. Each of the 80 bottles will be labeled as follows:

Date:

Organism:

Suspending Fluid:

Count Per ml:

Bottle Number:

The bottles will be stored at $3° \pm 2°C$ in two or more refrigerators.

Certification of Stock Culture

It is important that the stock spore suspension prepared for use throughout this project be as clean as possible, free of contaminating microorganisms, not subject to high mutation and of suitable resistivity to ethylene oxide gas exposure. To assure that a suitable spore culture is used, the JPL Technical Representative will approve the spore culture for use in the project. In order to provide data for this approval, the following tests will be conducted:

1. Microscopic examination including gram and spore stains.
2. Culture of the stock suspension on Trypticase Soy Agar containing 1:2, 000, 000 brilliant green dye (this medium will inhibit gram positive microorganisms thereby allowing for the detection of gram negative contaminants).
3. Examination of sub-cultures on broth and agar plates for the presence of non-pigmented mutants.

4. Paper spore strips containing 1×10^5 spores will be prepared and the resistance of these strips to ethylene oxide will be compared with that of B. subtilis spore strips made from freshly prepared spore suspensions made by BBL.

The information derived from the above examinations will be forwarded to the JPL Technical Representative for comment and approval. The stock spore culture will not be used until approval from the JPL Technical Representative is secured. It is estimated that this part of the Phase I Test Plan will require approximately 30 days for completion.

II. SELECTION, PROCUREMENT AND PREPARATION OF TEST PIECES

The following test pieces will be used for Phase I. These will be procured in the size and quantity indicated below:

Test Piece	Size	Material	Quantity	Notes
Test tubes-capped	20 x 150 mm	Glass	1500	Morton caps
Glass tubes-open	10(ID) x 110 mm	Glass	1500	
Capillary tubes	1(ID) x 130 mm	Glass	1500	
Glass strips	15 x 50 mm	Glass	1500	
Metal strips	15 x 50 mm	316 Stainless Steel	1500	
Plastic strips	15 x 50 mm	Polypropylene	1500	

All test pieces will be washed in hot detergent solutions, rinsed three times in de-ionized water and dried. The glass and metal test pieces then will be placed in racks or suitable containers and sterilized in a hot air

oven at 160°C for two hours and the plastic pieces will be sterilized by autoclaving for 30 minutes at 121°C in suitable containers. Following sterilization the test pieces will be placed in suitable racks or containers for subsequent inoculations with the test spores. Placement of the pieces will be as follows:

Test tubes- capped with Morton caps and placed in metal racks, 40 per rack.

Glass tubes - placed in 150 mm Petri dishes, 10 per Petri dish.

Capillary tubes - placed in 150 mm Petri dishes, 100 per dish.

Glass, metal and plastic strips - placed in 150 mm Petri dishes, five strips per dish.

It is estimated that the above selection, procurement and preparation of test pieces will require approximately 45 days.

III. INOCULATION AND BIOLOGICAL ASSESSMENT OF TEST PIECES

1250 of each of the six test pieces will be inoculated with 1/10 ml of a suspension of the test spores containing 1×10^6 spores per 1/10 ml. These inoculations will be done under aseptic conditions. The inoculation conditions for the pieces will be as follows:

Test tubes - place inoculum in bottom of tube and replace the Morton closure.

Open tube - place inoculum in the middle of the tube no less than 50 mm from each end. Return the tubes to the Petri dishes.

Capillary tubes - allow 1/10 ml (or an amount containing 1×10^6 spores) to be drawn up into each tube. Return each tube to the Petri dish.

Glass, metal and plastic strips - inoculate each strip on one side only with 1×10^6 spores and replace the cover of the Petri dish.

Following the inoculation of the test pieces they will be placed in an incubator at 30-35°C for drying. When the test pieces are visually dry, two of each piece will be aseptically added to 10 ml of TSB for initial attribute data. Five of each piece will also be used for initial enumeration data. These data will be summarized and reported to the JPL Technical Representative prior to packaging and shipment of the pieces to JPL for vacuum treatment.

It is estimated that this part of Phase I of the contract will be accomplished in 30 days.

IV. PACKAGING AND SHIPMENT OF TEST PIECES TO JPL

Upon approval of the JPL Technical Representative all inoculated test pieces, with the exception of 50 of each that are to be retained as non-vacuum controls, will be packaged and shipped air mail special delivery to:

Mr. Alexander Irons
Jet Propulsion Laboratory
California Institute of Technology
4800 Oak Grove Drive
Pasadena, California 91103

The criteria for the shipping packages for the test pieces will be as follows:

1. The primary packages containing the pieces will be rendered sterile by a method other than ethylene oxide treatment prior to receiving the test pieces.
2. The placement of the inoculated strips in the primary package will be done under aseptic conditions or in a Class 100 laminar air flow cabinet.
3. All cushioning material used in the primary package will be sterilized by a method other than ethylene oxide.
4. The test pieces will be placed in the initial packages in a manner so as to avoid breakage and to prevent the rubbing of one piece against the other in the spore inoculated area.
5. All primary packages will be over-wrapped in secondary crush-proof package for shipping.
6. B-D will supply complete directions to JPL for the opening of the shipping carton and any other steps necessary before vacuum treatment of the pieces.
7. After vacuum treatment it is anticipated that the same packaging material can be used for the return of the test pieces to B-D.

V. VACUUM EXPOSURE OF TEST PIECES AT JPL

As soon as possible after the initiation of this Test Plan, the Principal Investigator will forward to the JPL Technical Representative an estimate of the total space that will be occupied by the test pieces when they are to be vacuum treated. JPL will use this information to determine if the vacuum exposure can be done in a single chamber run or if multiple vacuum treatments will be necessary to process all of the test pieces.

If more than one chamber run is required each run will be handled in accordance with the following general guidelines:

1. JPL personnel should open the outer packaging in accordance with instructions and use Class 100 conditions to manipulate the primary packaging or test pieces as required.
2. At least 50 of each type of test piece will be removed and returned to B-D without being vacuum treated. These pieces will serve as the shipping controls.
3. The test pieces to be treated will be placed in a suitable chamber at ambient temperature and a vacuum drawn of between 1×10^{-5} and 1×10^{-6} torr.
4. The vacuum shall be maintained for two weeks.
5. The test pieces shall be removed from the vacuum system and repacked under aseptic conditions for shipment back to B-D as soon as possible. Shipment should be by air mail special delivery.

The minimum time anticipated for the return of one vacuum treated load of test pieces is three weeks.

VI. ASSAY OF VACUUM TREATED TEST PIECES PRIOR TO ETHYLENE OXIDE EXPOSURE

Upon receipt of the vacuum treated test pieces and non-vacuum treated shipping controls from JPL the secondary packaging will be removed and the primary packages placed in an aseptic transfer cabinet. The test pieces will then be repositioned as necessary for storage under atmosphere pressure and ambient conditions of $45 \pm 10\%$ relative humidity and a temperature of $70 \pm 10°F$.

Once the test pieces are in storage a specific procedure will be used each time specimens are removed for testing. This procedure will involve the use of an aseptic transfer cabinet or Class 100 laminar air flow cabinet to assure that the test pieces do not become contaminated with other microorganisms.

As soon as possible after arrival in Baltimore, and after one and two weeks, the following test pieces will be removed from storage and assayed:

1. Two each of each test piece for attribute assay.
2. Two each of each test piece for enumeration assay.
3. Two of each non-vacuum control piece for attribute assay.
4. Two of each non-vacuum control for enumeration assay.
5. Two of each shipping control for attribute assay.
6. Two of each shipping control for enumeration assay.

Enumeration Assay Procedure

The purpose of the enumeration assay procedure is to determine the number of viable test spores on a test piece before or after various treatments. In all cases the results will be expressed as the number of spores

per test piece or the per cent of spores remaining as compared to an untreated control. All enumeration procedures will involve the use of strict aseptic techniques to avoid extraneous contamination. Each enumeration test will involve the assay of only one test piece of each type.

The test is performed by aseptically adding the piece to be tested in approximately 40 ml of sterile 1.0% peptone water contained in a 25 x 200 mm screw-capped tube. Following placement in the peptone water each tube will be placed in a Branson Ultrasonicator for 12 minutes. The Branson instrument will consist of a generator, A300; tank, LT-80 Power Control, PC-30. All inside surfaces of the tank shall be stainless steel. During use the tank fluid shall be an aqueous solution of 0.3% by volume Tween 90 or equivalent. The temperature of the tank fluid shall be at least 25°C and shall not exceed 37°C. The fluid in the tank shall be adjusted so as to be at least one inch above the level of the liquid in the tube being sonicated. For treatment of the tubes the frequency of the sonicator shall be set at 25 Kc/sec. The power output in relation to the bottom surface area of the tank shall be at least 2.3 watts/sq. in.

Following sonication the peptone water in each enumeration tube shall be treated as follows. Aseptically pipette 5.0 ml portions of the peptone water into five 100 mm diameter sterile Petri plates. When appropriate, make suitable dilutions of the peptone water in sterile distilled water and pipette five 5 ml portions of each dilution into 100 mm diameter sterile Petri plates. Add 20 ml of sterile molten (50°C) TSA to each plate and

mix the contents by gentle swirling. Allow the mixture to solidify. Incubate the plates at 32-35°C and perform colony counts after 24, 48 and 72 hours. Record all counts greater than 300 per plate as TNTC. Incubate negative and low count plates (less than 25 colonies) for an additional 24 hours before the final count. Add the total number of colonies on the five replicate plates in each dilution and using this number calibrate the total number of viable organisms recovered from the test piece.

Attribute Assay Procedure

Test pieces will be assayed according to the indicated schedule to determine whether any procedures used had any effect on inactivation of viable spore inocula. All test pieces except capped test tubes (20 x 150 mm) will be assayed for spore viability by placing of the test pieces (under aseptic conditions) into tubes containing sterile Trypticase Soy Broth (TSB). Capped test tubes will be assayed for inoculum viability by aseptic introduction of 10 ml sterile TSB into the tubes. All TSB tubes will be incubated at 35°C for a period of up to 21 days. The culture tubes will be examined periodically and a record maintained of the number of positives (growth) and negative (no growth) tubes. In all cases sterile tubes shall be inoculated with TSB in order to preclude possible contamination of the test media; these will serve as negative controls.

VII. EVALUATION AND VERIFICATION OF MICROBIOLOGICAL ASSAY METHODS

Throughout each step of the Phase I Test Plan, pilot studies will be conducted to standardize, step-by-step, all manipulative operations. The objective will be to eliminate as many variables as possible prior to the actual use of the specific operation in the research. These manipulative procedures will be repeated a number of times and sufficient data developed to detect and evaluate the variables and to allow for the possible correction and improvement of the various techniques. Particular attention will be paid to variations involving the distribution of organisms in inocula, the accuracy of pipettors, variations in pipetting, culturing, counting and other manipulations. It is anticipated that at an early date, several quick, low-cost tests will be designed to optimize the laboratory equipment and practices, and to provide an estimate of statistical variability.

VIII. PRESENTATION OF TEST PLAN DATA

The routine mechanism for the presentation of data from Phase I will be the Monthly Technical Reports. These reports will detail the progress made during the reporting periods, discuss any technical problems encountered and their resolution and review briefly the research program for the coming month. Monthly and Quarterly Technical meetings may also be held.

Data are to be presented to JPL in several forms but primarily through the use of tables showing the results of the assays. Data shown may also be presented in histogram form and graphs made to show the effect of an independent variable. Written descriptions of test procedures will accompany

data presentations. When appropriate, summations and interpretations of the data will be made and specific recommendations provided.

IX. DESIGN AND FABRICATION OF ETHYLENE OXIDE CHAMBER

In accordance with the contractural requirements, the JPL Specification Number GMO 50518 and the documented modifying agreements, Becton, Dickinson and Company will secure three price quotations for design, fabrication and installation of the test chamber (Envirco, Vacudyne Corporation and S.Blickman Inc.). Selection of the responsible bidder will be made with priority upon price, proximity to Cockeysville, Maryland and estimated time of delivery. The Procurement Office of JPL and the JPL Technical Representative will be presented with back-up information concerning the selected bidder, documentary evidence concerning the unsuccessful bidders and the "draft" agreement between B-D and the selected bidder for approval. Upon receipt of approval a contract will be implemented with the selected fabricator. If desirable, a preliminary design conference will be scheduled by the JPL Technical Representative, the Fabricator and Project Officer for a review of design criteria, materials of construction, controls, etc. Upon receipt of the preliminary design submission (approximately 15 days after notice to proceed) the Fabricator will be instructed to proceed with construction.

Periodic design and construction progress conferences will be held at the Fabricator's plant at least twice a month and the JPL Technical Representative will be immediately notified of any significant delays in the fabrication schedule. In the event of such a delay a proposal will be presented

to the Technical Representative for correction of the problem and an estimate of the overall effect of such a delay on contract performance. Upon completion of fabrication and assembly of monitoring equipment, an in-part final check-out process will be scheduled with advance notification of the JPL Technical Representative. If the design criteria have been successfully met by the test chamber, it will be packed and shipped to Cockeysville, Maryland for installation. Upon completion of installation the unit will be rechecked and tested by B-D personnel prior to final payment of the Fabricator. Test data of this check-out will be furnished to the JPL Technical Representative. Primary operating flow diagrams and operating procedures will be prepared and furnished to the JPL Technical Representative and appropriate personnel will be trained in correct operating procedures prior to utilization as a test chamber.

X. EQUIPMENT, SUPPLIES AND MATERIAL - PURCHASE AND MODIFICATION

Upon receipt of the government-furnished Low Infrared Analyzer (LIRA) we will coordinate the recalibration with Mine Safety Appliance. It has been estimated that the purchase of a new head will allow a calibration of the JPL LIRA for the gas mixtures to be employed on this contract. After modification the unit will be checked out with the appropriate gas mixtures.

A complete list of supplies, material and equipment required for performance of Phase I of the Test Plan will be prepared. Appropriate

purchase descriptions will be developed and when necessary, prior approval for purchase will be obtained from JPL (only on items of equipment in excess of $1, 000). The delivery schedule for each item of equipment will be coordinated to assure on-time delivery and to assure elimination of delays to research activities. As required by the contract, appropriate records will be kept for capital equipment.

TEST PLAN

PHASE II

CONTRACT:	The Development of Parametric Data for the Establishment of an Ethylene Oxide Cycle for the Decontamination of Spacecraft
CONTRACT NO:	952169
FOR:	The Jet Propulsion Laboratory California Institute of Technology 4800 Oak Grove Drive Pasadena, California 91103
SUBMITTED BY:	Becton, Dickinson and Company Rutherford, New Jersey
DATE SUBMITTED:	November 19, 1969
PRINCIPAL INVESTIGATORS:	Dr. G. Briggs Phillips Dr. Jerry J. Tulis

Reference is made to Test Plan, Phase I, October 15, 1968, where a detailed discussion of the following outline was presented.

I. Preparation and certification of Bacillus subtilis var niger spores.

II. Selection and procurement of test pieces.

III. Inoculation and biologic assessment of test pieces.

IV. Packaging and shipment of test pieces to JPL under aseptic conditions.

V. Vacuum exposure of test pieces at JPL facility.

VI. Assay of vacuum-treated test pieces (during storage under ambient conditions) prior to ETO exposure.

VII. Design and fabrication of ETO chamber as per JPL specifications and purchase of other required equipment and materials.

Sections I, II, and III have been essentially completed. Sections IV and V have been altered as per agreement with JPL; vacuum exposures will be conducted in the locale of the Becton, Dickinson Research Center, thereby not necessitating the packaging and shipment of test pieces. The vacuum exposures will be conducted at the Department of Aerospace Science, North Carolina University, Raleigh, N. C. Due to the large chamber size of the vacuum chamber, all test pieces will be exposed to a vacuum of 1×10^{-5} to 1×10^{-6} torr in a

single trial. Section VI will be complied with in accordance with the protocol presented in Phase I except that no shipping controls will be assayed and the procurement of enumerative and attribute data will be simplified in the following manner. Test pieces will be aseptically placed in tubes of trypticase soy broth and subsequently insonated as previously indicated. Following sonication, 3 aliquots of 1 ml each will be removed and placed into 100 mm diameter sterile petri plates. Twenty ml of sterile molten (50C) trypticase soy agar will be added to each plate and mixed with the inoculum by gentle swirling. The plates will be allowed to solidify and then will be incubated at 32-35C. Colony counts will be made after 24, 48, or 72 hours; all counts greater than 300 per plate will be recorded as TNTC. Negative plates will be incubated for an additional 24 hours before discarding. The total number of colonies from the 3 replicate plates will be used to calibrate total recoverable bacteria from the respective test pieces. No further dilutions of the initial tubes will be made for enumerative data; the tubes will be handled as outlined in Section VI for attribute data.

EXPERIMENTAL PARAMETERS FOR ETHYLENE OXIDE EXPOSURES

Test pieces will be subjected to an equilibration period of 2 weeks at ambient conditions (45 +10% RH, 70 +10F) after vacuum treatment and prior to ethylene oxide exposure.

Controls

Positive controls will represent test pieces that have not been exposed to ethylene oxide treatment. These pieces will be inoculated with sterile trypticase soy broth at the same time that the ETO exposed pieces are inoculated and incubated along with exposed pieces. The positive controls will serve as a check on the possible deleterious effects on the inoculated test pieces by the various laboratory manipulations and storage, exclusive of ETO exposure. Also, the ability of the specific test medium used to support growth of the test organism will be validated. Negative controls will be performed by inoculation of known sterile tubes with trypticase soy broth. These tubes will be incubated along with "test" tubes and will serve as a check on the sterility of the liquid medium.

Process Steps

1. Place the test pieces within the experimental chamber and seal the chamber.

2. Induce air to flow through the chamber. This air shall be continuously circulated through the chamber and then returned to the heat exchanger, where it will be heated and humidified before being returned to the chamber. Water

vapor being introduced into the circulating gases shall be controlled in such a manner which will not cause condensate to form on any portion of the chamber or load. Continue to circulate the heated, humidified air.

3. After the humidification period, stop the circulation of air within the chamber.

4. Apply sufficient vacuum to the chamber and gas circulation system to produce a vacuum in the range of 70 ±5 torr within a period of 24 minutes. This time rate of change of pressure shall not exceed 2.0 pounds per square inch per minute.

5. Introduce the decontaminant into the chamber through a heat exchanger, which is capable of heating the decontaminant to a maximum temperature of 55C. The temperature control system of the heat exchanger shall be such that it is capable of controlling the temperature of the decontaminant. As the gas enters the chamber, it shall be approximately the temperature at which the test is being conducted. Introduce the decontaminant at a rate which will permit reaching the desired concentration within 30 ±15 minutes. After the desired concentration is reached within the chamber, circulate, humidify and heat the decontaminant for the required exposure period. Automatic gas make-up shall be used to maintain the desired concentration of decontaminant during this period.

6. After the specified exposure period apply a vacuum as outlined in step 4.

7. Return the chamber to atmospheric pressure within a period of 45 ±15 minutes by allowing air at ambient temperature to enter the chamber through an absolute bacteria retentive filter. Then flush the chamber with absolute filtered ambient air until 2 air changes have been accomplished completing the decontamination cycle. Flushing will be done at ambient pressure.

8. Open chamber and remove load.

Parametric Evaluations

The following specified conditions (variable and non-variable) were decided upon at a meeting of the JPL Technical Representative (Mr. A. Irons) and B-D Assistant Project Officer (Dr. J. Tulis).

1. Pre-exposure humidification phase of cycle (non-variable)

    a. Time: 4 hours
    b. Relative humidity: 45%
    c. Temperature: 42C

2. Sterilization phase of cycle (variable)

    a. Time: 4, 8, and 16 hours
    b. Relative humidity: 30, 40, and 50%
    c. Temperature: 30, 40, 50C
    d. Ethylene oxide type: Freon 12
    e. Ethylene oxide concentration: 400, 600, and 800 mg/l

3. Five replicate test pieces shall be used for each experimental point. Therefore, the total number of test pieces of each of the 6 types used will be: 5 replicates x 3(time periods) x 3(relative humidities) x 3(temperatures) x 3(ETO concentration) = 405. Attempts to reduce the number of test situations from the present 81 to approximately 50 will be made with the assistance of Triangle Research Institute (TRI) systems analysis personnel. A reduction of this nature that would not compromise the anticipated experimental results would greatly enhance the possibility of extending the somewhat restrictive parameters imposed upon these studies; i.e., especially during the pre-exposure humidification cycle.

Presentation of Data

The routine mechanism for the presentation of data from Phase II will be the Monthly Technical Reports. These reports will detail the progress made during the reporting periods, discuss any technical problems encountered and their resolution, and review briefly the research program for the coming month. Monthly and quarterly technical meetings may also be held.

Data are to be presented to JPL in several forms but primarily through the use of tables showing the results of assays. Data shown may also be presented in histogram form and graphs made to show the effect of an independent variable. Written descriptions of test procedures will accompany data presentations. When appropriate, summations and interpretations of the data will be made and specific recommendations provided.

Biological Sciences Communication Project
THE GEORGE WASHINGTON UNIVERSITY

5 January 1972

The following eight-page blueprint foldouts are of poor graphic quality and do not give a legible Xerox print:

Decontamination test chamber No. 10866
7 January 1970 DX-5039-1177-40 A

Decontamination test chamber
7 January 1970 DX-5039-1177-40 B-E

Recirculation motor-blower assembly
21 October 1969 DX-5039-1177-110

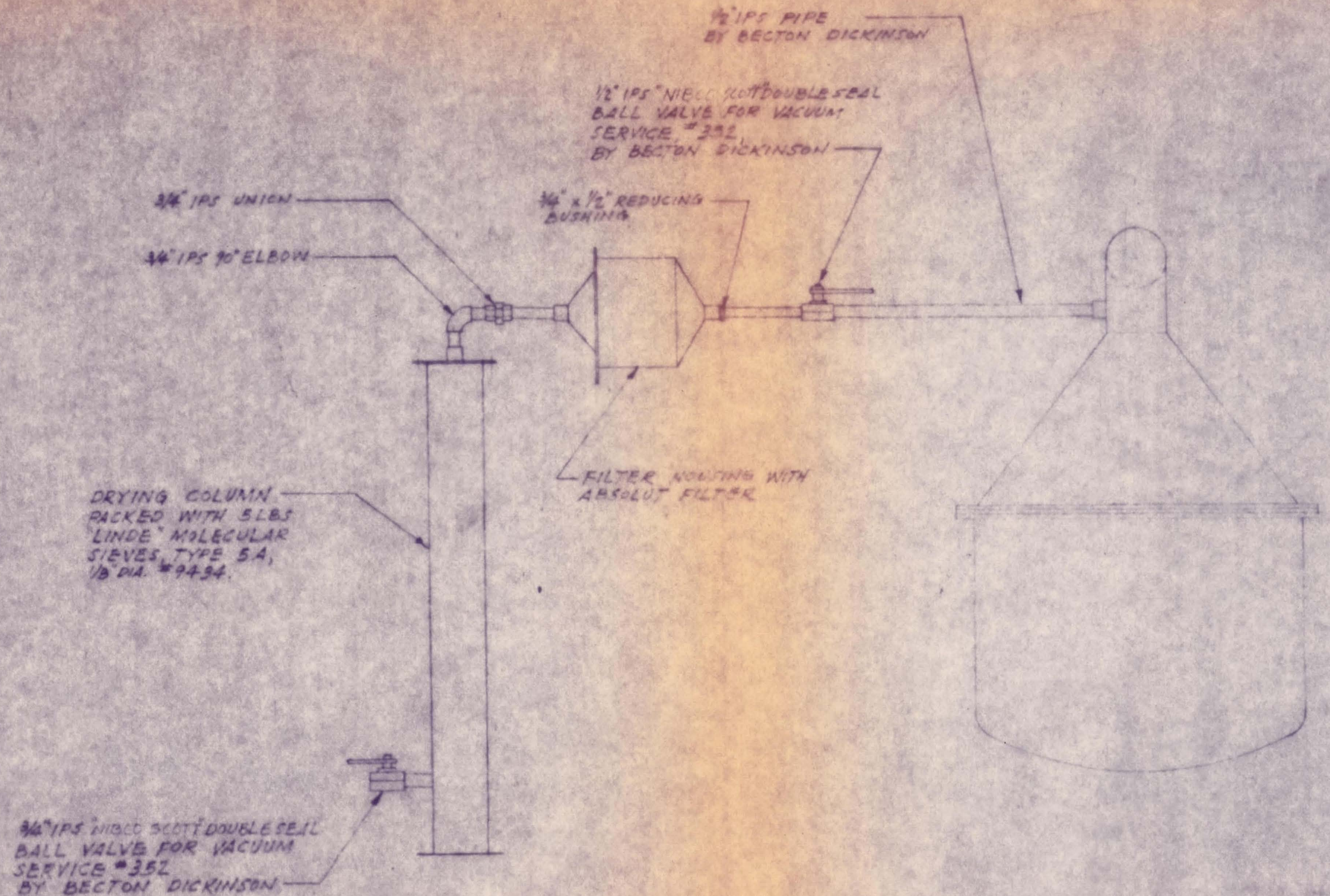
Mild steel-welded angle support stand
20 March 1969 DX-5039-1177-100

Chambers evacuation system
24 February 1969 DX-5039-1177-80

Systems instrumentation
24 February 1969 DX-5039-1177-70

General Assembly
Basic stainless steel chamber
24 February 1969 DX-5039-1177-20

The original blueprints were prepared for Becton-Dickinson, Rutherford, New Jersey by S. Blickman, Inc., 536 Gregory Avenue, Weehawken, New Jersey.



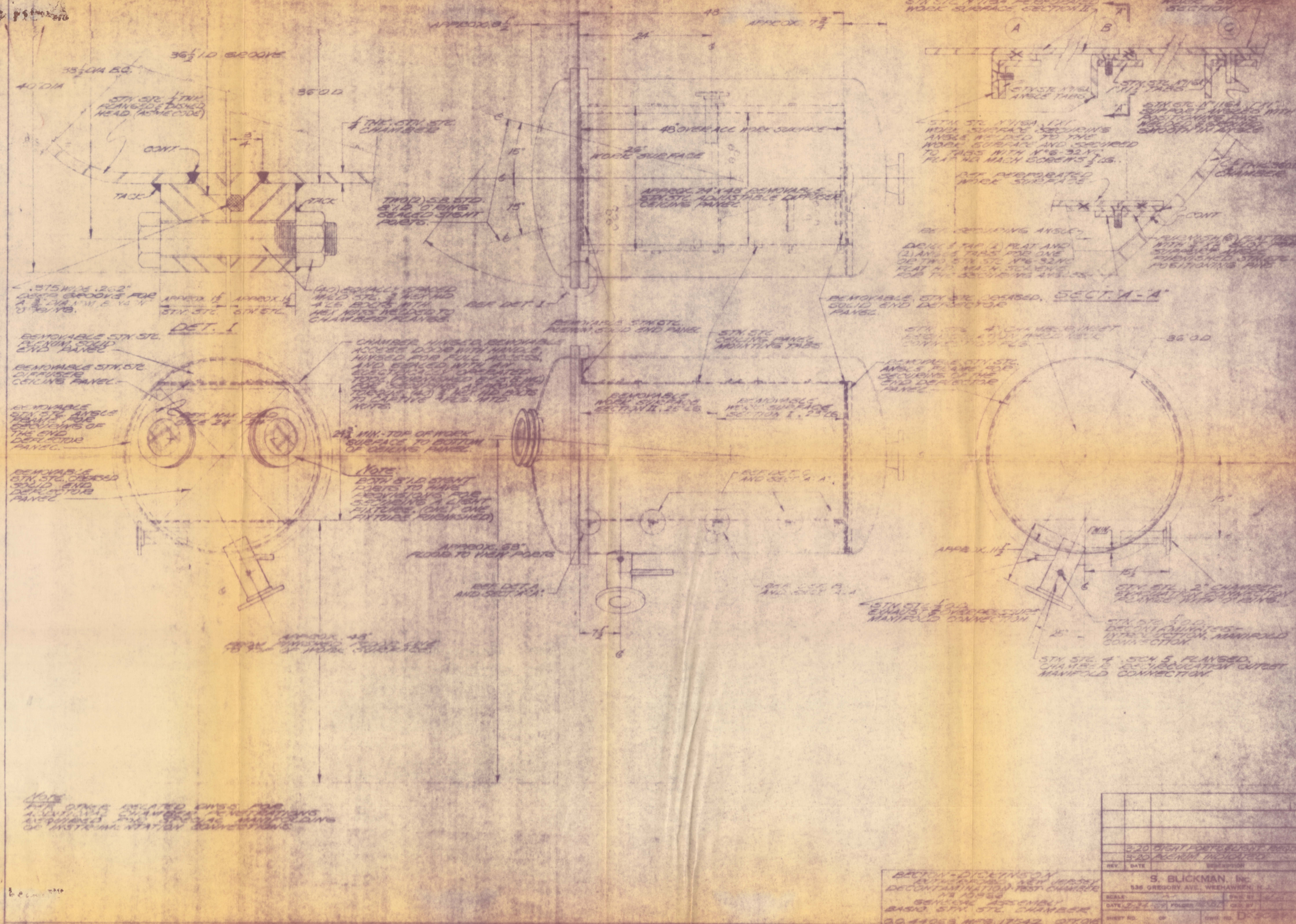
BECTON - DICKINSON
RUTHERFORD, NEW JERSEY
Nº 10866
DRYING SYSTEM PIPING
DECONTAMINATION TEST CHAMBER
O.O. # 44068 MFG. # 17542

S. BLICKMAN, INC.
536 Gregory Ave., WEEHAWKEN, N. J.

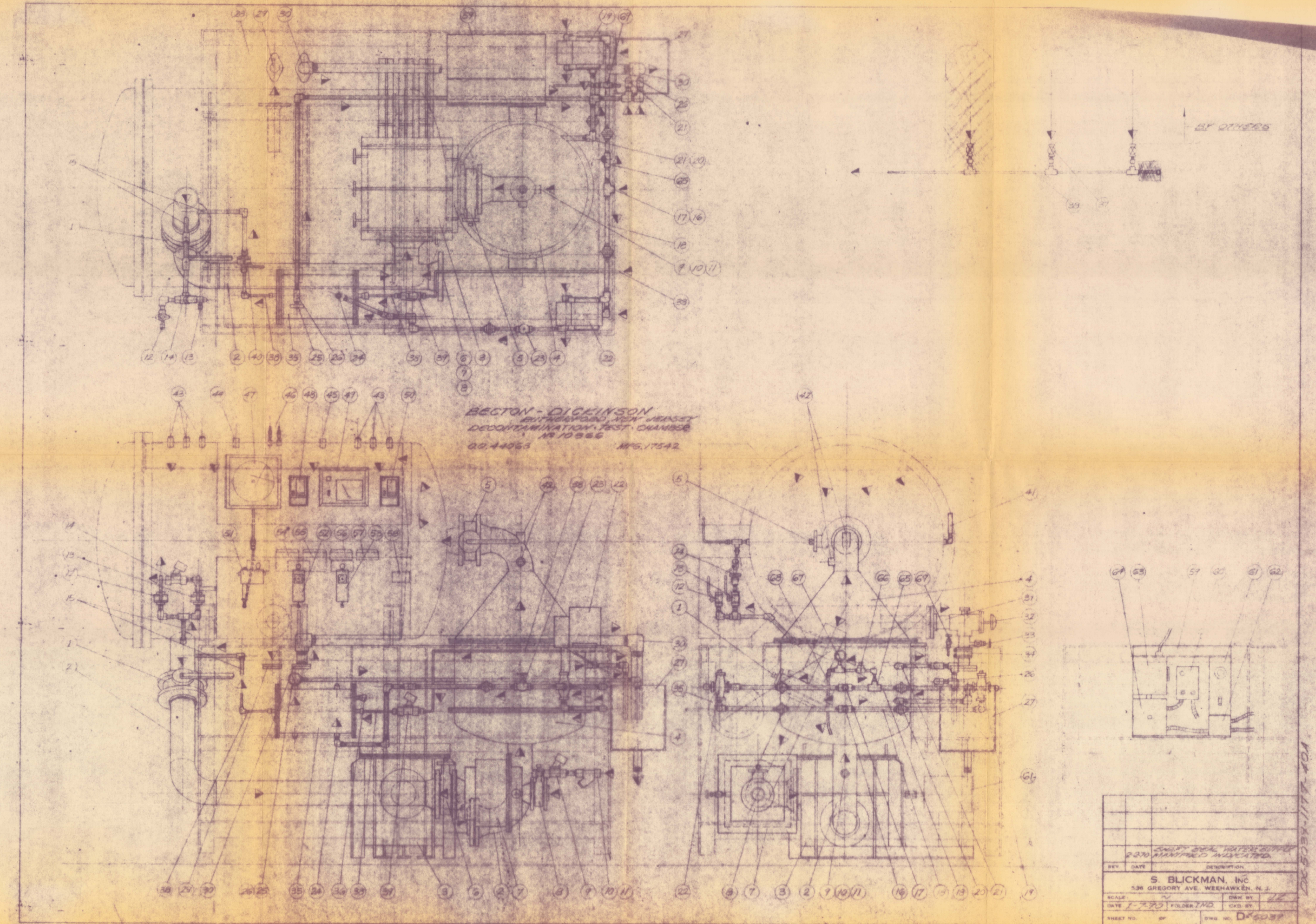
SCALE ~		DWN. BY	CUTRO
DATE 28 MAY 70		CKD. BY	
REV.		FOLDER	
		DWG.	

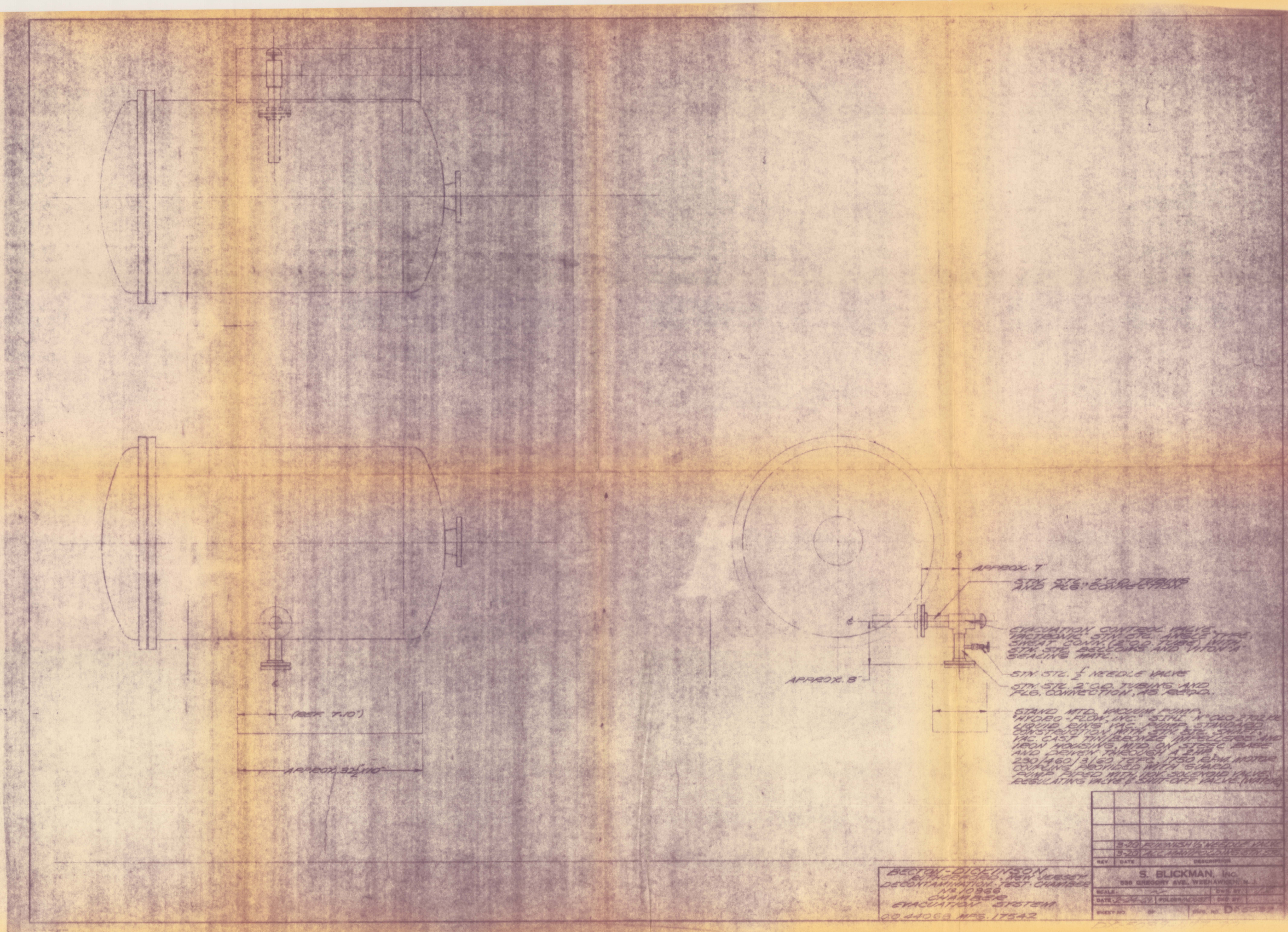
DWG # BX-5029-1177-125

BRUNING 40-213 10893



DET. I
SECT. "A-A"
CONT.
TACK
48" OVERALL WORK SURFACE
36" O.D.
40" DIA
NOTE
BECTON-DICKINSON
RUTHERFORD, NEW JERSEY
DECONTAMINATION TEST CHAMBER
GENERAL ASSEMBLY
BASIC STN. STL. CHAMBER
3-20 SIGHT PORTS & LIGHT REQD.
3-20 PLENUM INDICATED
REV.
DATE
DESCRIPTION
S. BLICKMAN, Inc.
536 GREGORY AVE., WEEHAWKEN, N. J.
SCALE
DATE
FOLDER
DWN. BY
CKD. BY
SHEET NO.
OF
DWG. NO.
DX-5037-1177-20


BECTON - DICKINSON
RUTHERFORD, NEW JERSEY
DECONTAMINATION · TEST · CHAMBER
· № 10966
O.O. 44063
MFG. 17542
BY OTHERS
2-2-70
SHAFT SEAL WATER SUPPLY MANIFOLD INDICATED.
REV
DATE
DESCRIPTION
S. BLICKMAN, INC
536 GREGORY AVE. WEEHAWKEN, N. J.
SCALE
DATE 1-7-70
FOLDER IND.
DWN BY
CKD. BY
SHEET NO.
OF
DWG. NO. D-6037



(REF. 7.10")
APPROX. 32 1/2 X 10"
APPROX. 7
STN. STL. 2" O.D. TUBING AND FLG. CONNECTION.
EVACUATION CONTROL VALVE, VACTRONIC STN. STL. ANGLE TYPE, SWEAT CONN. (2" O.D. TUBE) WITH STN. STL. BELLOWS AND VITON 'A' SEALING MATL.
APPROX. 8"
STN. STL. 1/2 NEEDLE VALVE
STN. STL. 2" O.D. TUBING AND FLG. CONNECTION, AS REQD.
STAND MTD. VACUUM PUMP, "HYDRO-FLOW, INC." SIHI N° OLO 2702 KE LIQUID RING VAC. PUMP, STANDARD CONSTRUCTION WITH STN. STL. SHAFT, VAC. CAST TIN/BRONZE IMPELLERS AND IRON HOUSING, MTD. ON STEEL BASE AND DRIVEN THROUGH A 2 HP. 230/460/3/60 TEFC. 1750 RPM. MOTOR COUPLING PROVIDED WITH GUARD. PUMP PIPED WITH 110V. SOLENOID VALVE, REGULATING VALVE & SHUT-OFF VALVE. (WATER)
3-20 FURNISH 1/2 NEEDLE VALVE
3-20 ALL MANIFOLDING STN. STL.
REV. DATE DESCRIPTION
S. BLICKMAN, Inc.
536 GREGORY AVE. WEEHAWKEN, N. J.
SCALE
DATE 2-24-67
FOLDER
DWN. BY
CHD. BY
SHEET NO. OF
DWG. NO.
BECTON-DICKINSON
RUTHERFORD, NEW JERSEY
DECONTAMINATION TEST CHAMBER
No. 10966
CHAMBER
EVACUATION SYSTEM
CO 44068 MFG. 17542

NOTE:
REF. COMPONENT AS INDICATED ON DWG. DX-1177-40A

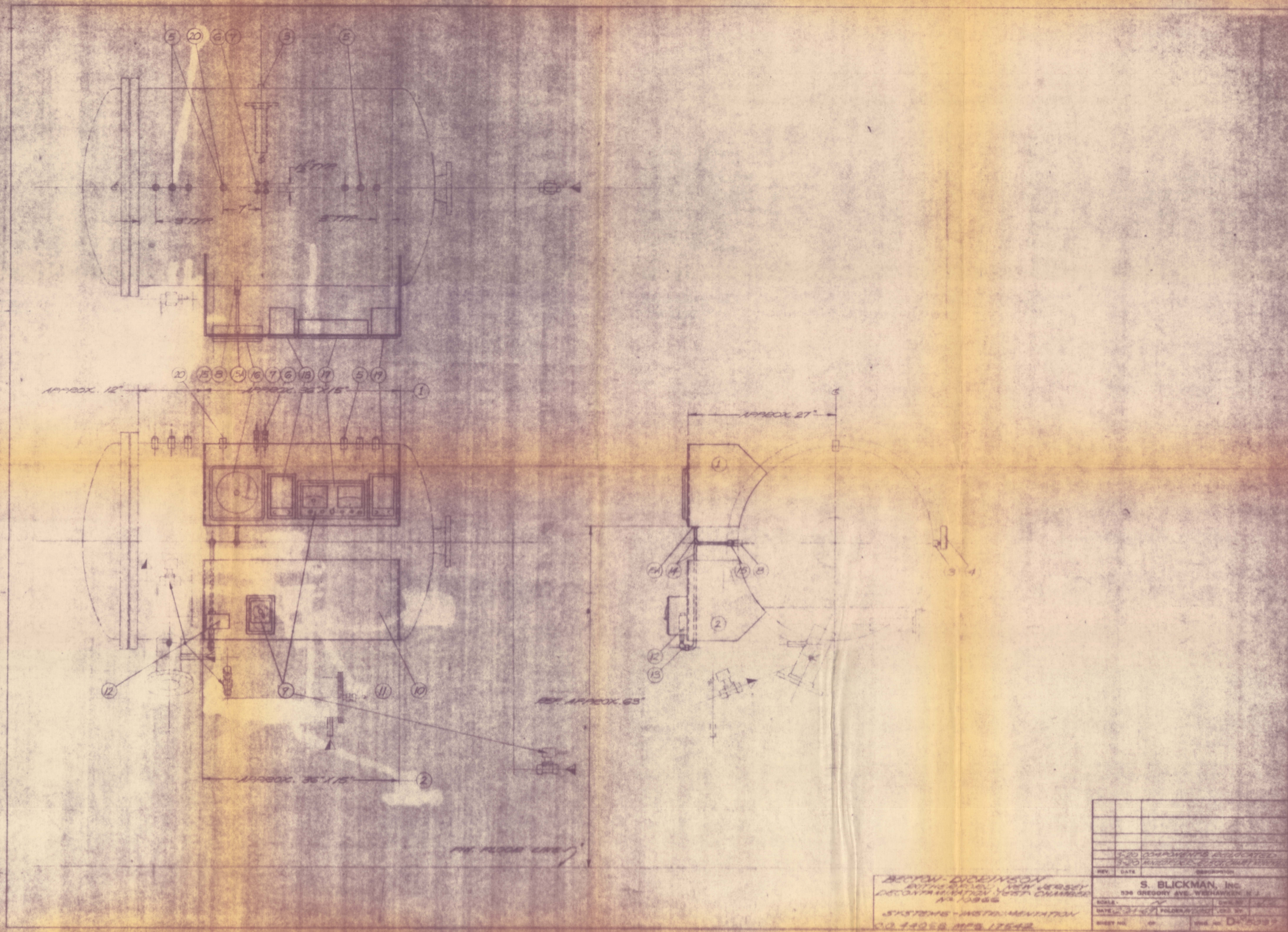
REV	DATE	DESCRIPTION
	2-2-70	ITEM # 61 UPDATED

BECTON - DICKINSON
RUTHERFORD, NEW JERSEY
DECONTAMINATION & TEST - CHAMBER
Nº 10866
G.O. 44868 MFG. 17542

S. BLICKMAN, INC.
536 GREGORY AVE., WEEHAWKEN, N. J.

SCALE:		DWN. BY	J.L.
DATE: 1-7-70	FOLDER	CKD. BY	
SHEET NO.	OF	DWG. NO.	D-5097

DX-5097-1177-40B-C



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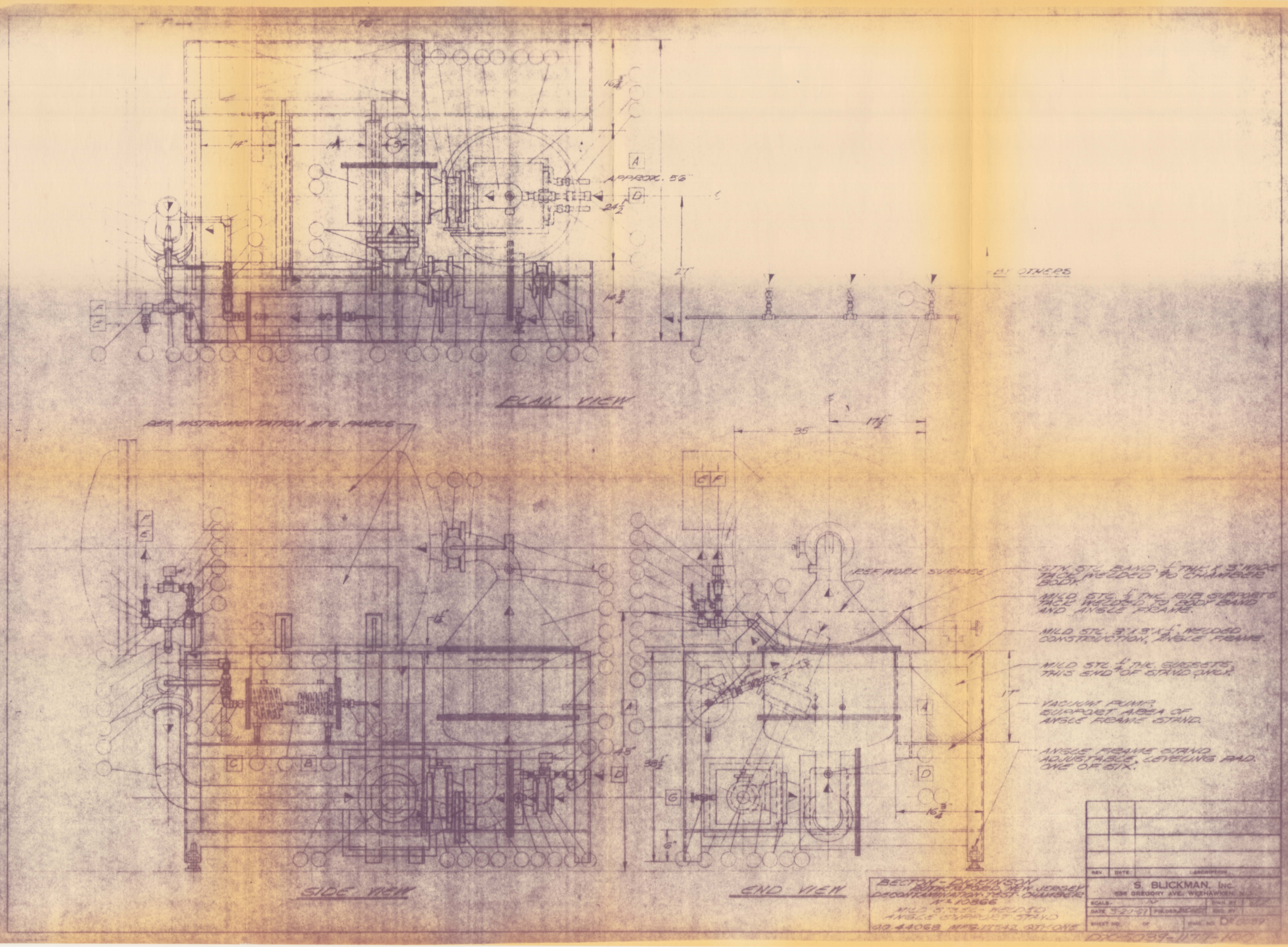
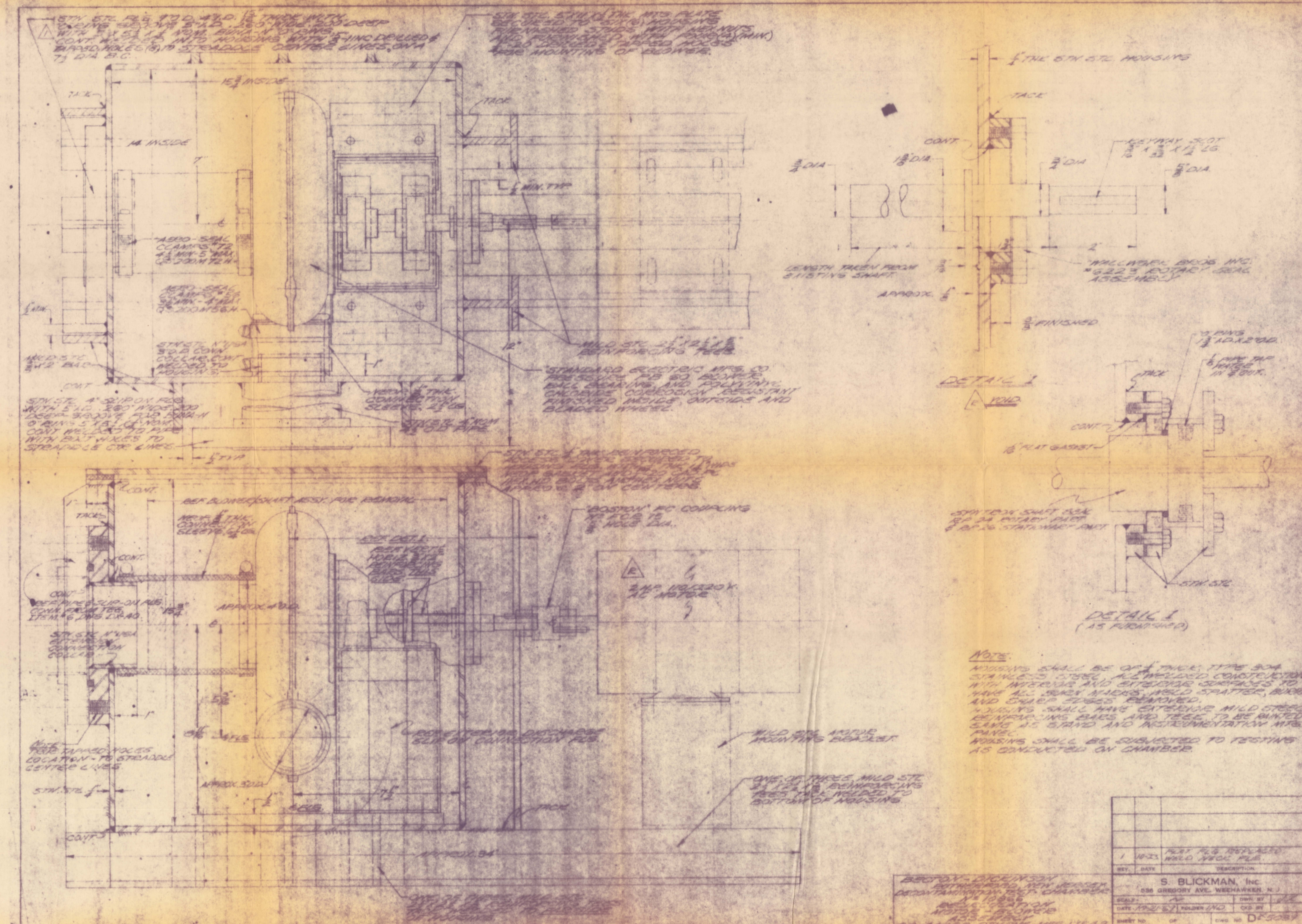
APPROX. 27"
REF. APPROX. 65"
REF. FLOOR LINE
BECTON-DICKINSON
RUTHERFORD, NEW JERSEY
DECONTAMINATION TEST CHAMBER
No 10866
SYSTEMS - INSTRUMENTATION
CO 14058 MFS 17542
3-20 COMPONENTS RELOCATED
3-20 MINOR PANEL-ELECT. CHART RECORDER
REV.
DATE
DESCRIPTION
S. BLICKMAN, Inc.
536 GREGORY AVE. WEEHAWKEN, N.J.
SCALE
DWN. BY
DATE
FOLDER
CKD. BY
SHEET NO.
OF
DWG. NO. D-5059


PLAN VIEW
SIDE VIEW
END VIEW
APPROX. 56"
BY OTHERS
REF. INSTRUMENTATION MTG. PANELS
IPSF WORK SURFACE
STN. STL. BAND, 1" THK. x 3" WIDE TACK WELDED TO CHAMBER BODY.
MILD STL. 1" THK. RIB SUPPORTS TACK WELDED TO BODY BAND AND ANGLE FRAME.
MILD STL. 3" x 3" x 1" WELDED CONSTRUCTION, ANGLE FRAME.
MILD STL. 1/4" THK. GUSSETS, THIS END OF STAND ONLY.
VACUUM PUMP, SUPPORT AREA OF ANGLE FRAME STAND.
ANGLE FRAME STAND ADJUSTABLE, LEVELING PAD. ONE OF SIX.
BECTON - DICKINSON
RUTHERFORD, NEW JERSEY
DECONTAMINATION TEST CHAMBER
No. 10866
MILD STEEL WELDED
ANGLE SUPPORT STAND
O.O. 44068 MFG. 17542 QTY. ONE
REV
DATE
DESCRIPTION
S. BLICKMAN, Inc.
536 GREGORY AVE. WEEHAWKEN, N.J.
SCALE
DATE 3-20-67
FOLDER
DWN. BY
CKD. BY
SHEET NO.
OF
DWG. NO. D
D70-5039-1177-100


DETAIL 1
DETAIL 1
(AS FURNISHED)
NOTE:
HOUSING SHALL BE OF 1/4" THICK, TYPE 304 STAINLESS STEEL, ALL WELDED CONSTRUCTION WITH INTERIOR AND EXTERIOR SURFACES TO HAVE ALL BURN MARKS, WELD SPATTER, BURRS AND SHARP EDGES REMOVED.
HOUSING SHALL HAVE EXTERIOR MILD STEEL REINFORCING BARS AND TEES TO BE PAINTED SAME AS STAND AND INSTRUMENTATION MTG. PANEL.
HOUSING SHALL BE SUBJECTED TO TESTING AS CONDUCTED ON CHAMBER.
"STANDARD ELECTRIC MFG. CO
5 H.P. 110/220 V. AC MOTOR
MILD STL. MOTOR MOUNTING BRACKET.
APPROX. 94"
BECTON-DICKINSON
RUTHERFORD, NEW JERSEY
DECONTAMINATION TEST CHAMBER
Nº 10866
RECIRCULATION MOTOR-BLOWER ASSEMBLY
1 10-23 FLAT FLG. REPLACED WELD NECK FLG.
REV. DATE DESCRIPTION
S. BLICKMAN, Inc.
536 GREGORY AVE., WEEHAWKEN, N. J.
SCALE
DATE
FOLDER
DWN. BY
CKD. BY
SHEET NO. OF
DWG. NO. D-5089